Marshall Space Flight Center

FY 2000 ANNUAL REPORT

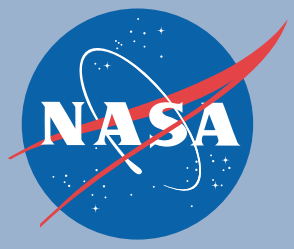
Statement of the Director

The turn of the century served as the backdrop for another exceptional year for Marshall Space Flight Center. The Center continued to exceed in its assigned areas by carrying the successes and high standards of the 20th century into the 21st. Our first commitment was to safety, and the workforce demonstrated this commitment by practicing the principles of safety in all aspects of operation.

The year 2000 was hallmarked by Marshall Space Flight Center's 40th anniversary. The Marshall Center hosted a community and Centerwide celebration to pay tribute to our proud history. Milestones were reached with the 100th Space Shuttle launch, and with the occupancy of the *International Space Station (ISS)*. The Payload Operations Center, which supports Station, began conducting integrated payload operations. On the research front, the creation of the National Space Science and Technology Center underscored Marshall's commitment to the pursuit of new technologies and benchmark science. The Chandra X-ray Observatory stunned the astronomy world with its never-before-seen images, earning the Chandra team the coveted Smithsonian National Air and Space Museum Trophy for Outstanding Achievement. As the Agency's Center of Excellence for Space Propulsion, we moved forward on Shuttle upgrades and advances in 3rd generation and in-space propulsion, and we excelled in our three mission areas: Space Transportation Systems Development, Microgravity, and Space Optics Manufacturing Technology.

The Space Transportation Directorate proved itself in meeting and exceeding the goals and challenges as the Agency's Lead Center for Space Transportation Systems Development. This quality teamwork will be essential as the Marshall Center begins the congressionally approved Space Launch Initiative. The Science Directorate flourished in its involvement of 550 microgravity research projects and implementation of 60 grants and contracts for Materials Science. As the Lead Center for Microgravity Research, Marshall completed its transfer of the very first microgravity payload to board *ISS*. The Space Optics Manufacturing Center completed an exhaustive year of work, forging new paths to the development of essential technologies to support the Next Generation Space Telescope. Under the management of the Flight Projects Directorate, hardware for the *ISS* continued to be developed and tested, and the orbiting science laboratory experienced its first significant growth. The Space Shuttle Projects Office (SSPO) met the tough task of continuous improvement and monitoring of the Space Shuttle elements. The SSPO successfully implemented friction stir welding to increase the weld strength of the external tanks. It also began phasing in the Advanced Health Monitoring System, a diagnostic tool for the Space Shuttle Main Engines. The Solid Rocket Booster team began work to eliminate the use of hydrazine, and the Space Shuttle Reusable Solid Rocket Motor team celebrated its 10th sequential year of on-schedule deliveries to the Kennedy Space Center.

I am pleased with the accomplishments of FY 2000. The example the Marshall Center has set is an honorable one. Our success is due to the outstanding dedication of our workforce. I look forward to leading the Marshall Space Flight Center through another incredible year.



Arthur G. Stephenson
MSFC Center Director

Marshall Values

The Marshall Space Flight Center team is committed to these core values.

People:

- **We** recognize that the people who work here are "most important"—and are our greatest strength.
- **We** create a safe and healthy environment.
- **We** encourage balance between personal and professional life.
- **We** enable personal and professional growth.
- **We** commit ourselves to the highest standards of integrity and ethical behavior.
- **We** reward and celebrate our accomplishments.
- **We** recognize individual and cultural differences and treat each other with dignity and respect.

Customers:

- **We** are accountable to our customers and are committed to their satisfaction.
- **Our** customers can depend on us to deliver quality products and services.

Excellence:

- **We** pursue excellence in our people and in everything we do.
- **We** promote continual learning and improvement.
- **We** hold one another accountable for doing what we commit to do.

Teamwork:

- **We** are a unified and interdependent team.
- **We** cooperate, communicate openly, and share ideas with each other for the common good.
- **We** seek and enable partnerships with other NASA Centers, other agencies, academia, industry, and our local and global communities.

Innovation:

- **We** promote innovation and creativity.
- **We** seek different ideas and perspectives.
- **We** are committed to making a significant difference.
- **We** are willing to accept well-assessed, selected risks in the pursuit of our goals—but never at the expense of safety.

These values serve as the principles that guide our decisions and behavior.

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Marshall Space Flight Center FY 2000 Annual Report

Introduction

The Marshall Space Flight Center (MSFC), a field center of the National Aeronautics and Space Administration (NASA), was established on July 1, 1960, with the transfer of land, buildings, property, space projects, and personnel from the United States Army.

Dr. Wernher von Braun was named the Center's first director. Under von Braun's guidance, MSFC's Mercury-Redstone vehicle boosted America's first astronaut on a suborbital flight in 1961. Marshall's first major program was the development of the Saturn rockets, the largest of which began sending man to the moon in 1969 and Skylab into orbit in 1973. Other successful projects in Marshall's history include the three Lunar Roving Vehicles, the three High Energy Astronomy Observatories, the Hubble Space Telescope, the Chandra X-Ray Observatory, and the Marshall-developed propulsion systems which launched America's first Space Shuttle.

Marshall remains one of NASA's largest field centers, occupying over 1,800 acres in Huntsville, Alabama and employing approximately 2,676 civil servants. This number includes employees in resident offices at prime contractor's facilities and at the Michoud Assembly Facility in Louisiana. Marshall's budget allocation was $2.2 billion and the 2000 economic impact in Alabama was $774 million including the impact of work performed by MSFC for other Federal Agencies.

During the past fiscal year, approximately 23,649 contractor personnel were engaged in work for the center.

Marshall's vision is to be the world's leader in space transportation systems, microgravity research, and space optics manufacturing technology; and to be a vital resource for the development and utilization of key scientific missions that will advance the frontiers of knowledge and human exploration. The employees of MSFC remain committed to this vision which is evidenced not only by our accomplishments over the past year but our dedication to mission success in the future.

Facilities

Area	1,841 Acres
Buildings	162
Structures	68
Square Feet	4.1M
Replacement Cost	$1.1B
One-of-a-Kind Facilities	75

MSFC Employment (FY 2000)

Civil Servants (permanent and temporary)	2,676
• 1,450 With B.A./B.S. Degrees	
• 580 With M.S. Degrees	
• 165 With Ph.D. Degrees	
Contractors	23,649

Contracts (FY 2000)

MSFC manages 951 active contracts, valued at $33.7 billion, awarded to contractors in 48 states and the District of Columbia.

MSFC Workforce by State*

Alabama	9,563
Utah	5,305
California	3,980
Louisiana	2,542
Massachusetts	654
Florida	506
Illinois	374
Connecticut	315
Nevada	298
Virginia	285
Texas	239
Maryland	231
Arizona	171
Minnesota	139
Wisconsin	138
Colorado	131
Indiana	126
Georgia	124
Iowa	122
All Other Locations	1,044
Total	**26,287**

* *Civil servants, contractors, subcontractors, and vendors working in these states.*

Safety and Mission Assurance

At Marshall Space Flight Center, safety is at the forefront of everything we do. In the Safety and Mission Assurance Office (S&MA), our goal is to assure that MSFC is established as number one in safety within NASA. As we move forward to meet our goal, we strive to prevent human injury and occupational illness and ensure the safety of all operations and projects. This policy extends beyond MSFC to include the public, astronauts and pilots, the NASA workforce, and high-value equipment and property. It is important to understand that S&MA influences every project and activity at MSFC, and our mandate will not be compromised.

Safety and Mission Assurance is committed to achieving excellence and is organized to effectively support the MSFC organizational structure through the co-location of key S&MA personnel into the major project offices and contractor plants. This strategy has proven to be invaluable in meeting our assigned roles and missions. This has also helped to promote safety in all facets of operational project and institutional support.

At MSFC we understand that, in order to be effective, we must look at challenges as opportunities to learn and to teach others about the importance of safety. It is with this philosophy that we are helping to change and shape the safety culture here at MSFC. We are working to ensure safety communications reach all levels of civil service and contractor employees. The year 2000 found S&MA continuing to develop, improve, and enact safety initiatives.

S&MA used the Agency Safety Initiative (ASI) model to reinvigorate the MSFC safety program. The Center Safety, Health, & Environmental (SHE) Committee, chaired by the Center Director, is a leading force in this effort. Clear goals were established and communicated through posters, charts, and backdrop badges that stated MSFC's safety goal. Information is communicated to the MSFC workforce in monthly meetings. Managers are members of the Central SHE Committee and are held accountable for ASI elements in their areas of responsibility. In addition, many of the managers serve as Area Managers. This assignment requires direct participation in the day-to-day safety activities. Since implementation, managers, supervisors, employees, and contractors work together and have taken on the shared responsibility for improving many of the elements of the Agency Safety Initiative. In FY 2000, 375 reports were received and processed through the Safety Concerns and Reporting System. Also during FY 2000, MSFC completed four safety program reviews: the Performance Evaluation Profile survey, the OSHA annual self-evaluation report, a Voluntary Protection Program (VPP) readiness evaluation, and a Safety Program Evaluation conducted by Thiokol.

Full employee involvement in the safety program has taken place with employee participation at various levels. Approximately 300 employees are Building Managers/Building Manager Assistants. A new safety committee for Center employees, the Marshall Safety Action Team (MSAT), was formed. The MSFC Safety Day Committee included employee representatives from each Directorate at the Center.

These activities have led us to a strong commitment to safety and more intensive involvement by MSFC employees. This impact is found in the more user friendly safety documentation, the inclusion of safety performance in job descriptions and performance evaluation plans, and the ensuring of public safety during testing at the Center. Training for all MSFC employees on safety issues was provided along with intensive training for supervisors to perform job safety analyses. During FY 2000, all Civil Service employees received one day of safety training provided by DuPont and MSFC Managers. Approximately 2,600 Civil Service and 400 Contractors were trained. Development of contractor safety performance evaluation methods to assist with hazard prevention and control was implemented as was a method to benchmark the safety programs at other NASA Centers. Other safety processes include:

- S&MA internet web pages contain pertinent employee safety information and are frequently updated.
- Risk management planning, consulting, and training are readily available to support project risk management and development. Currently, 46% of projects requiring S&MA support have approved risk management plans.
- All MSFC Safety and Quality Management System documentation is contained in a single integrated document library for ease of use.
- All major management meetings include a safety discussion.
- Managers and supervisors conduct monthly workplace occupational safety and health audits with employees and ensure employees have had proper safety training.
- Occupational safety and health information is widely disseminated using multiple medias.

A Contractor Safety Forum was established with recruited members from all on-site contractors. A monthly newsletter for on-site contractors to exchange safety-related experiences and information was established. Proposed safety performance evaluation standards for all future MSFC support contracts were developed.

Safety initiatives and metrics within S&MA are managed with the use of a RADAR matrix developed in FY 2000. The RADAR matrix is a web-based reporting system which provides a current "stop-light" style status of all S&MA projects and activities. It provides department managers with fast, specific information about their projects, identifies projects or activities where attention is needed, and allows them additional insight into how their personnel are performing. Weekly briefings assure S&MA personnel that their major concerns will be addressed by management and also allows broader visibility of S&MA functions.

Safety policy documents required safety analyses for all new potentially hazardous operations and facilities. Hazard analyses performed in FY 2000 included transportation of key International Space Station hardware.

FY 2000 Safety and Mission Assurance Metrics and Performance

Achieve a 60 percent increase in predicted reliability of the Space Shuttle over the 1995 baseline.

A reliability improvement of 67.2 percent was achieved during FY99. The total reliability improvement as a result of Shuttle upgrades including the Block II upgrade over the 1995 baseline is 84.7 percent. The Block II upgrade has not yet been flown. During FY 2000, plans were developed for the Block III upgrade.

Reduce lost time mishap rate by 20 percent per year compared to the FY98 baseline of 0.16 over 5 years and better the NASA goal each year.

Although this represents an improvement of 35% in the MSFC rate from the previous year, we have not yet achieved our goal. MSFC continued to hold Supervisor safety meetings and workplace audits to help reduce lost-time mishaps. Safety communications to ensure that all mishaps and

FY 2000 Safety and Mission Assurance Metrics and Performance Continued

close calls are reported and that information is disseminated throughout the Center were improved (fig. 1).

Complete incorporation of safety into the MSFC Integrated Document Library system by the end of FY 2000.

All safety guidelines and policy documents are under MSFC's Document Control Board and easily accessible via the web-based integrated document library. All MSFC safety documents have been incorporated into the MSFC Integrated Document Library system. There were 14 safety documents incorporated into the system with the earliest being baselined on 12/13/99 and the latest on 7/10/00. All activities related to safety are being audited in the Internal Audit Program in parallel with the ISO 9000 Audits.

Complete the OSHA Voluntary Protection Program Star certification by the end of FY 2000.

MSFC continued its endeavors to prepare for certification by conducting a Voluntary Protection Program readiness evaluation. During the year 2000 we improved the following elements:

Management Leadership

- Establishing a new Supervisors Safety Web Page (SSWP) to record statistics and provided information to managers/supervisors.
- A new contractor safety performance evaluation system is being developed.
- Performance evaluation profile surveys of all civil service and contractor employees are being conducted to assess effectiveness of the program.

Employee Involvement

- Initiated new safety mascot program – Safety Sam, Protective Pam, Dr. Know, Reuse-It-Rita, and Hazardous Harry were introduced on Safety Day.
- Initiated Dr. Know database – Center employees can ask a safety, health, or environmental health question. Database has search capability.
- Marshall Safety & Health Action Team (MSAT) established to involve employees. Conducted Safety Bowl contest for Center employees. Final game held on Safety Day; winners received a silver bowl.
- Contractor Safety Forum established to involve contractor personnel. Also, provides better communication and distribution of safety information.
- Participated in VPP Conventions.
- Safety, Health, & Environmental highlights distributed every Monday at Center Director's staff meeting and posted on Inside Marshall Web site.

Worksite Analyses

- Continued to write job hazard analyses and post on the web for Center employees' access.

Hazard Prevention and Control

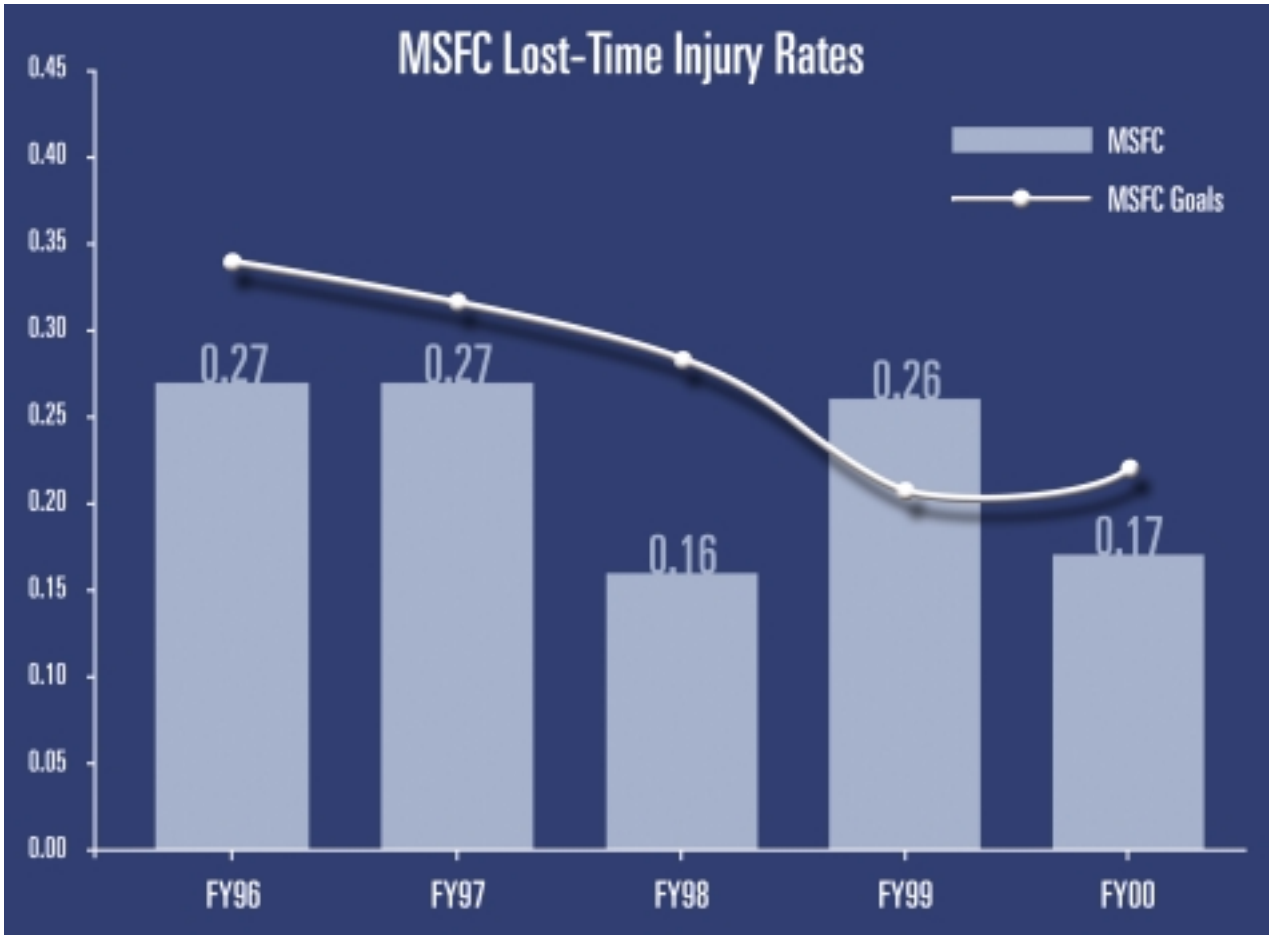
- Increased office safety meetings with metrics.
- Conducted safety audits in conjunction with the ISO 9000 audits.

Training

- Completed Safety 2000 (safety and health training for all civil service employees).
- Training all on-site contractor personnel in 2001.
- Providing Safety 2000 refresher training to all civil service employees in 2001

All MSFC projects successfully complete their safety reviews on time.

MSFC supported six in-house Payload Safety Readiness Review Boards and successfully completed five Johnson Space Center/Kennedy Space Center payload safety reviews on time during FY 2000.


MSFC Lost-Time Injury Rates
MSFC
MSFC Goals
0.45
0.40
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0.30
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FY96
FY97
FY98
FY99
FY00
fig. 1

Center of Excellence: Space Propulsion

Goal: Develop and maintain U.S. preeminence in space propulsion to enable the exploration and development of space.

Marshall Space Flight Center engineers and scientists are developing a wide range of advanced propulsion technologies needed to open the space frontier. As NASA's Center of Excellence for Space Propulsion, the Marshall Center leads the development of systems and technologies for the exploration and commercialization of space. Cutting-edge technologies under investigation run the gamut from new, durable materials that withstand extreme heat to tethers that can be used for propulsion.

The propulsion systems of the future – for both Earth-to-orbit and in-space applications – must be much safer, more reliable and dramatically cheaper than today's systems. NASA's emphasis on technology development is aimed at making future space propulsion systems more like current airline operations.

Since escaping Earth's gravity is the most expensive part of any space mission, NASA is concentrating on significantly increasing the performance of Earth-to-orbit propulsion systems. Technology development activities that could make a substantial impact on space propulsion within the next decade include: advanced nozzle concepts, such as the unique Aerospike engine; lightweight composite thrusters; composite housings, lines and ducts; and ceramic turbines. These innovative technologies are designed to enable a new Reusable Launch Vehicle (RLV) by early next decade.

Within the next couple of decades, RLVs could be powered by air-breathing propulsion systems that "breathe" oxygen from the air, instead of carrying all the heavy oxidizer onboard the vehicle. Rocket-based, combined cycle engines could result in a 15% performance increase over conventional space launch engines. Other off-board energy sources planned for the future include beamed energy propulsion and launch assists that use magnetic levitation to give a vehicle a "running" start.

More than 70 percent of all payloads need transportation beyond low-Earth orbit, so NASA is developing propulsion technologies to boost spacecraft to higher orbits. Advanced chemical engines, electrodynamic tethers, and solar thermal and solar electric propulsion are viable options for in-space transportation. Technologies being developed for interplanetary missions include fission, fusion and antimatter propulsion. Space sails are being pursued for interstellar travel.

Space Propulsion Highlights

The first demonstration of an electrodynamic tether as a propulsion system is planned for mid-2001. ProSEDS – the Propulsive Small Expendable Deployer System – will use an electrodynamic tether to lower the orbit of a spent rocket stage. Originally scheduled to fly in 2000, ProSEDS was delayed in a conscientious effort to ensure mission success. An internal review of the experiment was conducted against the backdrop of lessons learned from recent Mars mission failures. NASA decided to incorporate additional tests and relax the schedule so there would be sufficient time to assess results of ground testing and make any needed adjustments prior to flight. During the last year, components have been tested successfully and system-level testing is under way. Tether deployment tests and analysis of attitude dynamics for the ProSEDS end-body were conducted during the last year.

The High Performance Antimatter Trap (HiPAT) has been completed and checkout tests have been conducted with electrons and hydrogen ions. The Antimatter Trap's storage capability of one million charged particles has been demonstrated, indicating the

Trap is capable of handling its maximum capacity of one trillion particles. Tests at the maximum capacity are planned in preparation for filling the trap with actual antiprotons later this year.

Accomplishments with RLV propulsion technologies included successful fabrication of advanced, lightweight thrust chambers using metal matrix and polymer matrix composites. Chamber liners were fabricated using ceramic matrix composites. Additional testing of the ceramic matrix composite bladed disk—or blisk—in the simplex turbopump was successfully completed. Tests were also conducted on polymer matrix lines, valves and ducts, and the design of advanced, highly reliable valves has been initiated. Marshall engineers generated an analytical and experimental database for the advanced, unshrouded impeller.

NASA Marshall and its industry partners formed a team – the Integrated System Test of an Air-breathing Rocket (ISTAR) – to build and test the first flight-weight rocket-based, combined cycle engine system. The flight-like engine system will be designed to accelerate a self-powered vehicle to seven times the speed of sound. The engine system is planned for full-engine testing in the 2005 timeframe and could be demonstrated in flight by the end of the decade.

The revolutionary linear aerospike rocket engine for the X-33 technology demonstrator successfully completed a series of single-engine test firings. In addition, engineering design and analysis for the International Space Station Propulsion Module redefinition was performed.

Funding to initiate the design process for Marshall's proposed Propulsion Research Laboratory was obtained in FY 2000. This world-class laboratory is planned to centralize research that could improve access to orbit, open the space frontier for ambitious exploration, and strengthen the commercial development and human settlement of space. The architectural engineering design study for the multi-million dollar, 184,000-square-foot facility was completed in December 2000.

FY 2000 Space Propulsion Metrics and Performance

Deliver Fit-Checked MC-1 (Fastrac) engine to X–34 project in first quarter of FY00 and certify in third quarter of FY00.

After engine testing was moved from Stennis Space Center to the Santa Susana Facility, the fit-check of the MC–1 engine was successful. During FY00, the project team worked with Orbital Sciences Corporation on project approach, safety, and mission success issues. This identified that additional risk-mitigation activities were needed. In keeping with the principles of the Integrated Space Transportation Plan, the Office of Management and Budget and NASA agreed that additional funding could only be made available through the procurement for 2nd Generation Reusable Launch Vehicle design and development (NASA Research Announcement 8–30). When the X–34 project was evaluated against other proposals, it was determined that the investment required exceeded potential benefits. Although the X–34 experimental technology demonstrator project was discontinued in March 2001, it provided valuable experience with making rocket engines that are less expensive and more flexible, within a tight schedule.

Fly ProSEDS tether propulsion flight experiment at first opportunity after August 2000.

NASA is advancing technology in an effort to demonstrate an electromagnetic tether in a way it has never been used before — for propulsion. To ensure mission

FY 2000 Space Propulsion Metrics and Performance

success, an internal review of the experiment was conducted against a backdrop of lessons learned from NASA mission anomalies. It was decided to incorporate additional tests and relax the schedule so there would be sufficient time to assess results of ground testing and make any adjustments needed prior to flight. The ProSEDS mission is manifested for an FY01 flight.

Complete design and demonstration of a portable antiproton trap in FY00.

The High Performance Antimatter Trap (HiPAT) has been successfully designed and built. Checkout tests have been conducted with electron and hydrogen ion sources. Storage capability of 1 million charged particles has been demonstrated. This indicates that the trap is capable of handling its maximum capacity of 1 trillion particles. However, to test the trap's maximum capacity will require a sophisticated ion source, which is being procured from an outside company with a large backlog; delivery of the system is expected by the end of CY01.

After the ion source is received, the next phase of the demonstration, which will fill the trap to its maximum capacity, can proceed (projected for FY01). Once full capacity is demonstrated, detailed plans for filling the trap with actual antiprotons at Fermi or Brookhaven National Laboratory will be initiated (projected for FY02).

Demonstrate RLV propulsion technologies (including: lightweight long-life thrust cells; polymer matrix lines, valves, and ducts; advanced unshrouded impeller design; and advanced high-efficiency turbine design).

Lines and ducts were fabricated in FY00, with limited testing. Thrust cells, impeller, and turbine designs are planned for demonstration in FY01. Advanced Reusable Technology programs completed flow-path testing. Anticipated additional funding in FY01 will be utilized for continuation of fabrication and testing on flight-weight components.

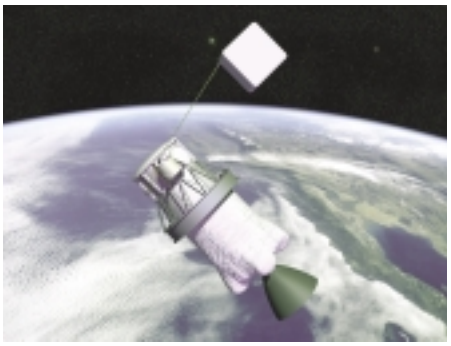
Define combined cycle flight demonstration in FY00.

The Integrated Systems Test of an Air-breathing Rocket (ISTAR) project screened three potential engine vehicle combinations and selected one powered by a strut-jet flow-path to carry forward for a hypersonic demonstrator (X–34B). Activities projected for CY01 include a Project Requirements Review (PRR) and a Conceptual Design Review (CoDR).

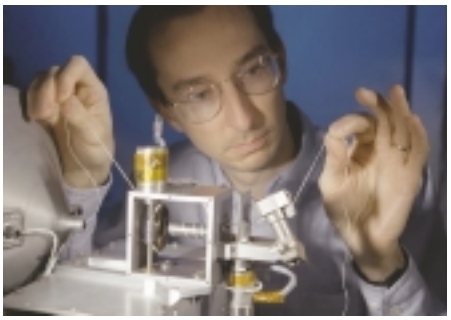
Complete X–33 XRS–2200 linear aerospike hot fire at Stennis Space Center.

Testing started in November 2000. Single engine hot-fire testing was completed. Flight engines 3 and 4 were mated and are in the test stand. Engine testing plans changed when an X–33 composite tank failed (see FY 2000 Advanced Space Transportation Metrics and Performance).

High Performance Antimatter Trap.



An artist's concept of NASA's Propulsive Small Expendable Deployer System (ProSEDS) as the tether is deployed in space.



Nonconducting part of a tether is inspected as it exits a deployer similar to the system to be used in NASA's ProSEDS flight experiment.

Space Transportation Systems Development

Goal: Lead the research and development of space transportation technologies and systems that support our customer's needs.

Space Shuttle Elements

The Space Shuttle Projects Office (SSPO)

The SSPO is responsible for executing the Space Shuttle Program (SSP) role assigned to MSFC. These responsibilities include activities associated with the Space Shuttle Main Engine (SSME), External Tank (ET), Solid Rocket Booster (SRB), and Reusable Solid Rocket Motor (RSRM). The SSPO is responsible for these propulsion hardware elements and associated systems, test and flight operations, and facilities. The SSPO manages the performance of civil service and industry personnel and resources in the planning, design, engineering, integration, development, production, testing, upgrade, delivery, and operations of the MSFC element projects, ensuring that safety, schedule, performance and cost goals are met.

External Tank at Kennedy Space Center.

External Tank

This has been a very successful year for the MSFC External Tank (ET) project. The project supported the Shuttle Program through the on time delivery of six Super Light Weight Tanks (SLWT) and contributed to the successful launch of four Shuttles with no In Flight Anomaly (IFA) of ET hardware. Through the use of innovation and hard work, the SSPO was able to surpass many of the goals that had been established at the start of the year. Some of the more significant technical and programmatic accomplishments were:

- Implementing Al 2219 domes and ogives for the hydrogen and oxygen tanks, which will reduce the cost of production and increase the margins of safety.
- Began implementing friction stir welding to reduce cycle time, enhance safety, and improve supportability.
- Closed the thermal protection IFA through venting the foam on the intertank.
- Instituted new process improvements such as Kaizen and Build Process Improvement Teams to reduce cycle time and streamline support requirements.
- Began weighing the tanks at the factory. This improves the process flow time the Kennedy Space Center and provides the payloads group with early weight data to better manage flight payloads.
- Delivered the least expensive SLWT to date. Manufactured ET 107 in 19 months which is a 3-month improvement over the average delivery time.
- Lead the industry in safety for hours worked vs. time lost due to injury.
- Began the in-house manufacturing of the intertank stringer panels, which reduced cost and improved cycle time.
- Avoided $385k of additional facility maintenance cost through the use of our Reliability Centered Maintenance program.

Space Shuttle Main Engine test firing.

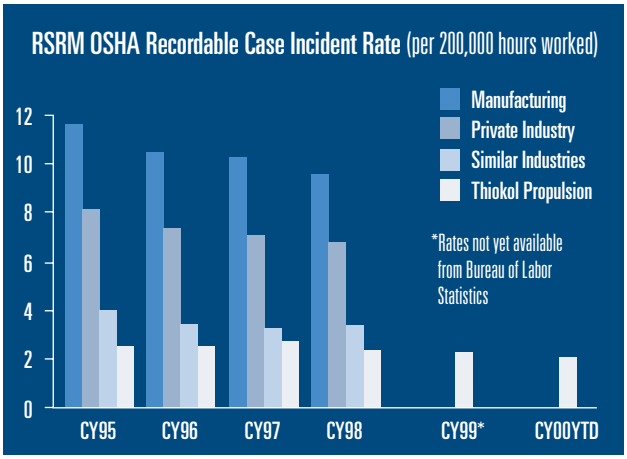
- Received the Werner von Braun Award for the successful implementation of the SLWT Project.
- Completed negotiations of the ET 6th Buy contract, which represents considerable savings per Tank over the previous contracts.

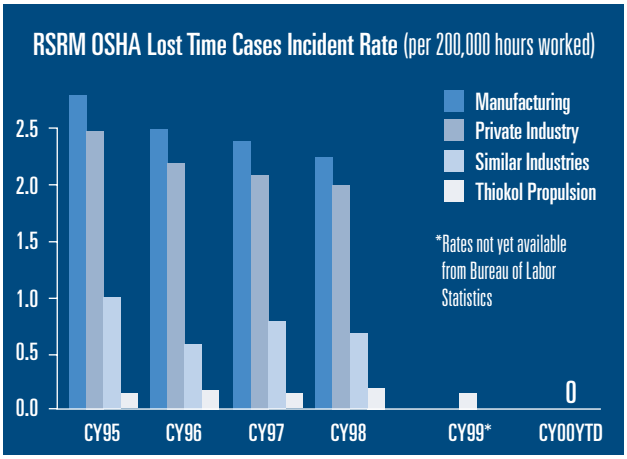
Most of these accomplishments were achieved because of the the professional and cooperative relationship that exists between NASA and Lockheed Martin, the External Tank prime contractor.

Space Shuttle Main Engine (SSME)

SSME continued its consecutive string of on-time launches extending from FY96 with no scrub or aborts attributable to SSME. Five missions were flown during FY 2000 with less than 0.25 in-flight anomalies per mission, well below the SSME goal. Certification test series were completed on Alternate High Pressure Fuel Turbo Pumps, and the design certification review was completed. The scheduled first Block II flight has slipped to third quarter of FY 2001. Program approval of the Advanced Health Monitoring System was accomplished, and design effort continued. Preliminary definition of requirements continued for a potential nozzle/ main combustion chamber upgrade to be considered by the Shuttle Program. Efforts continued in improving manufacturing processes and vendor control programs.

RSRM flight support motor firing.





Reusable Solid Rocket Motor (RSRM)

RSRM thrust performance met the predicted target for each of the four Space Shuttle launches in FY 2000. No significant anomalies were identified either during ascent or during subsequent postflight disassembly and inspection of the recovered motors. All RSRM segments for FY 2000 were delivered on schedule, making this the tenth consecutive year of on-schedule RSRM deliveries to Kennedy Space Center. Safety continues to be the principal focus in the manufacture of the RSRM and is reflected in the low job-related accident frequency rates at Thiokol Propulsion, which are well below the rates for similar industries, as published by the Bureau of Labor Statistics.

Because of low accident rates, Thiokol Propulsion qualified for the National Safety Council's Perfect Record Award for operating over 5 million hours without an occupational injury or illness involving days away from work (from September 1999 to present). In addition, National Safety Council Safe Driver Awards were presented to assigned company vehicle operators with no accidents during 1999. The RSRM program

continued to expand employee safety awareness, developing several safety initiatives throughout the year. These included Focus on Safety Day and Safety Start-up Day, when special safety inspections and/or meetings were conducted by employees throughout the plant; and Safety Month, which included special safety activities (e.g., several energetic material demonstrations, a special safety luncheon, and a unique OSHA regulations training class). Other safety initiatives include the Lockout/Tagout Training Manual update, machine guarding improvements, pressure vessel interlock improvements, and a live area safety review. The RSRM program has progressively improved productivity and quality over the last decade. Quality conformance for each motor exceeds 99.996 percent. RSRM manufacturing nonconformances have been lowered. A discrepancy reduction focus was recently initiated across all areas of the RSRM program, including suppliers.

Solid Rocket Booster (SRB)

The SRB workforce was proud of the 95 launches under UTC. Now, for the first time working under the USA banner, the team had no time to look back The STS–103/BI099 launch was just over two months away. The team put corporate identity behind them and did what they do best, provided perfect hardware for a perfect launch with STS–103. This was followed up with hardware for three more launches during Fiscal Year 2000; STS–99/BI100, STS–101/BI101, and STS–106/BI102. There were no in-flight anomalies for the SRB project during any of these flights.

With safety always being the number one concern, the SRB Element facilities ended the fiscal year with the following totals for days without a lost time injury: Assembly Refurbishment Facility, 96 days; Parachute Refurbishment Facility, 5,429 days; Refurbishment Operations, 22 days; and NonDestructive Test Operations, 1,292 days.

Damaged hardware during SRB splashdown initiated an aggressive review of more efficient and reliable methods to boost the number of fforward skirts in the fleet. Three initiatives were implemented to relieve this hardware shortage: Repair damaged forward skirts, upgrade test skirts to flight readiness, and begin the process to procure new forward skirts. Two forward skirts were retrieved from the Space and Rocket Center in Huntsville, Alabama to upgrade to flight readiness.

The Thrust Vector Control (TVC) system was identified as an area of improvement to reduce the risk to flight safety. The TVC system accounts for approximately 35% of the risks associated with the integrated vehicle based on the use of monopropellant hydrazine as the auxillary propulsion unit fuel source. To mitigate these risks, the SRB Project has initiated efforts to develop an advanced TVC system having increased reliability and reduced operational risks. The prime objective of the SRB Advanced TVC Upgrade Initiative is to measurably improve the flight safety and reliability of the SRB in the Shuttle vehicle. Secondary objectives are to improve ground safety by eliminating the use and processing of hydrazine, a known human carcinogen, and provide cost-effective supportability through the life of the shuttle program.

Lift-off of STS–99 from Launch Pad 39A

Implementation of the upgrades associated with the High Pressure Wash Facility Robotics System at Hanger AF were completed. The upgraded system was used to process the flight structures from STS–101/BI101. Total upgrades included a new gantry robot, a new host computer system, a new high pressure pump, and a complete refurbishment of the turntable. SRB also procured, installed, and verified a remote control operating system for Hanger AF high bay cranes. As a result, crane operations can continue during Phase II lightning warnings.

The SRB element also completed the upgrade of the Spray Cell in the Productivity Enhancement Complex (PEC) complex. This will enable the SRB project to perform more research, development and validation of new materials as well as increase troubleshooting capabilities.

Shuttle Upgrades

Safety is the number one priority for the Space Shuttle program and a new focus on upgrades demonstrates that commitment. The year 2000 brought formulation of five new propulsion safety upgrades that can potentially bring a 100 percent increase in propulsion safety and reliability. The Space Shuttle Main Engine (SSME) is implementing an advanced health management system that will enhance monitoring of the main engines. An extra large throat main combustion chamber and a new nozzle design are being studied to reduce the harsh engine environments, thereby increasing internal margins. The Solid Rocket Booster project is formulating an advanced thrust vector control system that will eliminate the use of hydrazine, a dangerous and volatile substance. Friction stir welding is being incorporated into the external tank's design to reduce weld repairs and increase weld strength. Finally, studies are in progress to increase structural margins within the Reusable Solid Rocket Motors via a modification to the propellant grain geometry. The propulsion safety upgrades program at MSFC is a five-pointed star that will leave safety shining brightly on America's Space Shuttle.

FY 2000 Space Shuttle Metrics and Performance

Maintain less than one in-flight anomaly (IFA) per mission.

SSME supported five launches in FY 2000 with less than 0.25 IFA's per launch. ET met the requirement, there were no IFA's for the ET. RSRM met the requirement. SRB had no IFA's. RSRM experienced one IFA in FY 2000 on STS–101. Based on the above, the SSPO met the IFA metric.

Streamline operations. Continue the transition of routine operations from a Government role of oversight to insight. Transition Shuttle Prime Contracts to the Space Flight Operations Contract (SFOC), based on project maturity and stability.

ET met the requirement. Both the quality and engineering organizations moved to an insight role for the approval of in-family nonconformances of ET flight hardware. SRB completed transition to SFOC in July 1998.

Achieve a 60 percent increase in predicted reliability of the Space Shuttle over the 1995 baseline.

Projections based on the Quantitative Risk Assessment indicate a 95-percent improvement (48-percent risk reduction) for ascent upon incorporation of Space Shuttle main engine upgrades (Block II: Fourth Quarter FY 2000).

SSME: First Flight of Block II has slipped to third quarter of FY 2001. Design continues on the SSME Advanced Health Monitoring System.
ET has begun the implementation of several key projects that will help obtain the 14 percent improvement in reliability. ET has begun implementation of the friction stir welding project and the A1 2219 Domes and Ogives that will increase weld strength and greatly reduce weld defects. The overall improvement in reliability is currently being evaluated.

Evaluate improvements in Shuttle systems safety, operability and cost by incorporating upgrades such as: Upgraded solid rocket motors or new liquid propulsion reusable first stages, and ET friction stir weld and repair processes

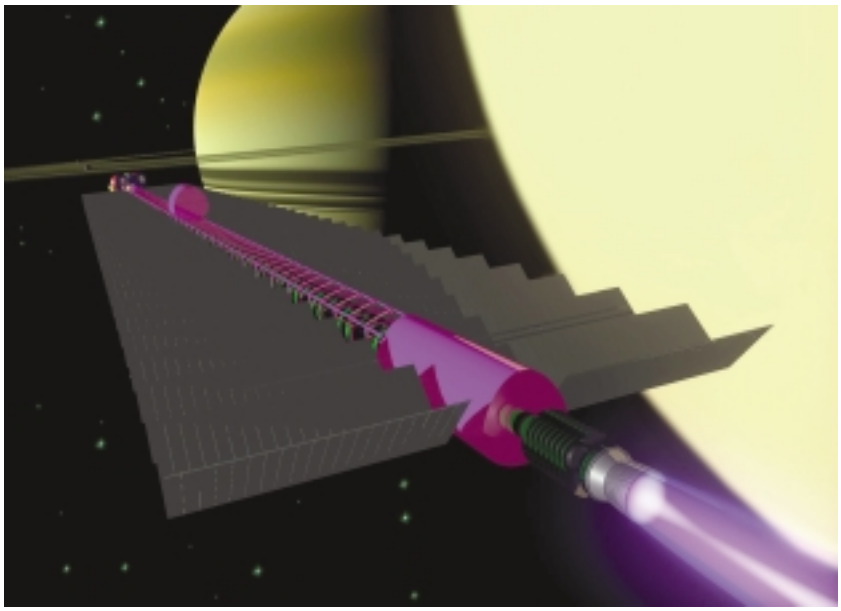
ET has met the friction stir weld objective through the implementation of friction stir welding on the longitudinal welds for the hydrogen and oxygen barrels.

Advanced Space Transportation Technology

Congressional approval of the $4.85 billion Space Launch Initiative (SLI) underscores the Marshall Space Flight Center's success in leading our nation's space transportation endeavors. SLI is an essential part of NASA's Integrated Space Transportation Plan, an investment strategy for diverse space transportation activities. This new initiative is a strategic approach to revolutionize space transportation. The comprehensive, long-range plan is designed to dramatically increase the safety and reliability and lower the cost of space transportation. SLI will maximize convergence between commercial, NASA and Department of Defense mission needs, technology requirements and operations considerations.

Through SLI, NASA will invest in risk-reduction activities to enable full-scale development of commercially competitive, 2nd Generation Reusable Launch Vehicles (RLVs) around mid-decade. These commercial space launch vehicles could be operational early next decade. The first SLI funding allocation, $290 million in FY 2001, resulted in NASA Research Announcement 8-30 for 2nd Generation RLV systems engineering and architecture definition, including risk reduction and technology demonstrator definition.

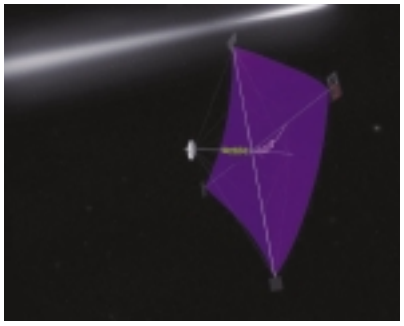
NASA created the new 2nd Generation Reusable Launch Vehicle Program office at the Marshall Center to lead the effort. The 2nd Generation RLV Program will build on NASA's experimental technology demonstrators and current launch vehicles, on joint NASA/



An artist's concept of a fusion-powered space vehicle approaching the Saturn moon Titan.

industry studies, and on national space policies to develop new materials, structures, propulsion systems, computers and other technologies needed to meet the Program's goal of significantly increasing safety to a 1 in 10,000 chance of loss of crew and reducing payload launch costs from $10,000 per pound today to $1,000 per pound.

NASA is partnering with industry to investigate potential markets that enable new science missions. Technologies will be developed to directly support market demand. Spearheading the technology development effort is Marshall's Advanced Space Transportation Program – our nation's central technology program for all future space transportation systems. Innovative new tools for managing technology development came online within the last year. The Integrated Technology Assessment Center was established with partners in industry and academia to analyze advanced space transportation systems to help prioritize technology investments and continuously measure progress being made to achieve NASA's ambitious goals. NASA also rolled out its new Space Transportation Information Network, an Internet-based information system to capture and disseminate technology development and research results to the space transportation community.



An artist's concept of a space sail.

FY 2000 Advanced Space Transportation Technology Metrics and Performance

Begin flight tests of the X–33 and demonstrate key technologies in CY 2000.

When Lockheed Martin's lightweight composite tank failed during testing in late 1999, they decided to replace it with aluminum tanks. Consistent with the terms of the cooperative agreement, Lockheed Martin reviewed the additional cost needed to complete the project and determined that the potential commercial launch market could not justify the investment. In keeping with the principles of the Integrated Space Transportation Plan, NASA and the Office of Management and Budget agreed that the X–33 technology demonstrator could compete for additional funding under NASA Research Announcement 8–30 for 2nd Generation Reusable Launch Vehicle design and development. When evaluated against other proposals, it was determined that the investment required to flight test the X–33 vehicle exceeded the benefits that could be gained. The X–33 project was concluded in March 2001, when the cooperative agreement expired. In addition to providing data about composite tanks, valuable lessons learned included new information about metallic thermal protection systems and aerospike engines, as well as the need for more government involvement in such partnerships.

An artist's concept of a Hypersonic spacecraft.

Complete X–34 captive carry tests in FY 2000.

Captive carry tests were completed in July 2000.

Initiate flight of the X–34 and demonstrate key technologies in CY 2000.

A joint NASA/Orbital Sciences Corporation review of the X–34 project conducted in the summer of 2000, revealed the need to redefine the project scope and schedule, including increases in technical insight, hardware testing, and integrated systems assessment. In keeping with the principles of the Integrated Space Transportation Plan, the X–34 project was required to compete for additional funding under NASA Research Announcement 8–30 for 2nd Generation Reusable Launch Vehicle design and development. When evaluated against other proposals, it was determined that the investment required exceeded the potential benefits, and the X–34 project was terminated in March 2001. Valuable lessons learned from this technology testbed included how to design and develop a 60k rocket engine on a tight budget and schedule. Knowledge generated will be applied to future reusable launch vehicles.

Complete Spaceliner 100 technology roadmap in FY 2000.

Initial roadmaps were completed and are a part of NASA's Integrated Space Transportation Plan.

Demonstrate 2nd Generation Reusable Launch Vehicle technologies by the end of CY 2000 (including: non-autoclave processing and LOX-compatible composite structures; composite joining; integrated structures and TPS; and hot structures and TPS).

Composite joining and hot structures and TPS objectives were completed in FY 2000. Due to funding constraints, the non-autoclave processing and LOX-compatible composite structures demonstration was cancelled. This technology is being reevaluated for a longer-term ground-demonstration program. The integrated structure testing is planned for FY 2001.

Complete 250k hybrid motor testing in the first quarter of FY 2000.

Testing of the 250k hybrid motor was completed.

Complete ground demonstration of 100-percent design life on the NSTAR ion engine in FY 2000.

Ground demonstration of 100-percent design life on the NSTAR ion engine was completed.

Complete combined cycle propulsion flight demonstrator definition in the second quarter of FY 2000.

A potential flight demonstrator concept, the X–43B, was identified.

Complete 500-hour test of the 10 kW Hall Electric Thruster in FY 2000.

The 500-hour test of the 10 kW Hall Electric Thruster test was completed.

Demonstrate densified liquid oxygen and hydrogen for RLV application.

The liquid oxygen skid demonstration was completed at NASA's Glenn Research Center.

Conduct X–40A approach and landing test.

The X–40A rollout was completed in May 2000. Seven drop-test flights are scheduled for CY01.

Launch the SHARP–B2 flight experiment.

The SHARP–B2 flight experiment was launched on September 28, 2000.

Complete proof and structural load tests of X–33 composite LH2 tank.

In 1999, the first of two conformal, load-bearing composite liquid hydrogen flight tanks failed following pressure and loads testing. This failure was due to microcracking, leading to gaseous hydrogen infiltration, which produced higher than expected core pressures. Lockheed Martin declined to invest additional funds, as provided in the cooperative agreement with NASA. When the X–33 project was evaluated against other 2nd Generation Reusable Launch Vehicle proposals, the cost to continue the project outweighed the benefits and the cooperative agreement expired in March 2001. The test data generated defined the boundaries of composite tanks and is now part of an extensive "lessons learned" knowledge base.

Build and deliver X–38 deorbit propulsion stage for integration into the flight demonstrator in late FY 2000.

The X–38 deorbit propulsion stage is at NASA's Johnson Space Center for integration with the flight demonstrator.

Complete Rocket-Based Combined Cycle (RBCC) flow-path testing in FY 2000.

Flow-path testing of two RBCC flow-path concepts from Aerojet and Rocketdyne was completed under the Advanced Reusable Technologies project. This activity will investigate flight-weight structural designs in 2001, and is then schedule for completion.

Complete X–37 design in FY 2000.

The initial design review of the X–37 was completed in March 2000.

Continue to upgrade facilities and maintain safe, cost-effective state-of-the-art test capabilities.

MSFC completed the Solar Thermal Test Facility during FY 2000. Activation of all gas systems and mirror systems was completed in the first quarter of FY 2000.

MSFC modernized three facility control systems with fiber-optic transmissions, graphic display interface control panels, and commercial-off-the-shelf programmable control logic environments. These control systems completely replaced obsolete toggle-switch panels and wiring used since the 1960s. These upgrades were applied to non-Rocket Propulsion Test Management Board/Stennis Space Center facilities (i.e., Test Stands 115, 300, and 4699).

MSFC completed upgrades and maintenance to Test Stand (TS) 116. Based on National Rocket Propulsion Test Alliance/Stennis Space Center facility rankings, TS 116 is currently the country's top-rated mid-thrust-range component facility. Critical maintenance was required to both mechanical and structural hardware. The facility has been completely repainted and reconfigured. All mechanical systems have been cleaned, repaired, and/or replaced. TS 116 was reactivated in February 2000.

An artist's concept of a Two-Stage-to-Orbit spacecraft.

Microgravity

Goal: Lead NASA's Microgravity Research and Space Product Development Programs, and develop and maintain capabilities to meet national research objectives.

Microgravity Research Program Office

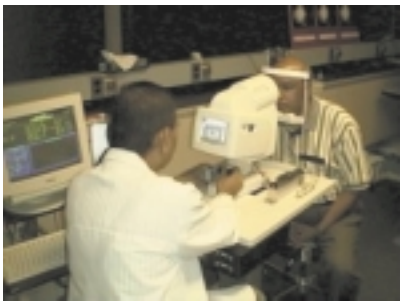
The Microgravity Research Program Office continued to successfully administer NASA's guidance and support to research the effects of gravity in chemical, physical and biological systems. This office assisted both public and commercial researchers by managing the development of major research facilities targeted for public research over five disciplines and commercial research over three disciplines of prime interest. *ISS* research facilities were funded by the Office of Space Flight through the *ISS* program. Additionally, the Microgravity Research Program Office identified and prepared smaller research payloads that are available for the early utilization of the *ISS*, thus providing accelerated research opportunities for long microgravity exposure. Similarly, the program maximized microgravity access via the Space Shuttle by providing access to two flights in FY2000 and by preparing research payloads for additional flights in FY2001. The program also continued to provide terrestrially-based microgravity access by providing for 11 parabolic aircraft flights and two sounding rocket flights, as well as access to short-duration microgravity available in the program's drop towers. The Microgravity Research Program continued to pursue disciplinary research in biotechnology, materials science, fluid physics, combustion processes, and diverse areas of fundamental physics through grants and hardware developments funded by the Office of Biological and Physical Research (BPR).

Microgravity Research Science Highlights

Research was conducted on the nature and structure of matter and energy at the atomic and molecular scales. Research examined the nanostructure and function of materials in nonliving systems, in systems from living organisms, and within living cells and tissues. Many of these studies will directly enhance human safety in spaceflight and life on Earth.

Several of the top research findings of the Microgravity Research Program (MRP) are highlighted below. Researchers of NASA and National Eye Institute (NEI) are collaborating in the development of a non-invasive, automated point-and-shoot fiber optic system that uses dynamic light scattering (DLS) for the early detection of cataracts. The system can be used as a diagnostic tool for indicating development of cataracts or can be used to evaluate the efficiency of drugs aimed at preventing or slowing the development of cataracts.

A group of JPL scientists have reported observation of Josephson junction effects in an array of sub-micron slit apertures near the liquid He lambda transition. Josephson phenomena of this type could be used in a superfluid gyroscope to make precise measurements of the rotation of the helium container or a spacecraft that surrounds the liquid helium. Research on colloidal suspensions have shown that 3-D ordered colloid systems with lattice constraints comparable to the wavelength of visible light might find important applications as photonic crystals, optic filters and chemical sensors.



Manuel Datiles, of the National Eye Institute, tests the opacity of Rafat Ansari's eye with the newly patented fiber optic imaging probe.

Detailed structural analysis, by diffraction techniques, of crystals resulting from experiments carried out in the STS-95 mission has led to the determination of a very accurate macromolecular structure for proteinase K which allowed the resolution of the protein's active site. This material is a model system for studying enzymes that may be used in the design of drugs for inhibiting certain protein degration reactions.

Recent Combustion research has produced a completely unexpected burning pattern: spiral shaped flames on the surface of a burning disk. Although spiral patterns have been seen in wide range of chemical and biological systems, no one had observed them amongst the complex flows of mixing gases that

occur when the fuel and oxygen molecules must diffuse to find one another. Experiments should provide the first opportunity to derive spiral patterns from basic physics equations.

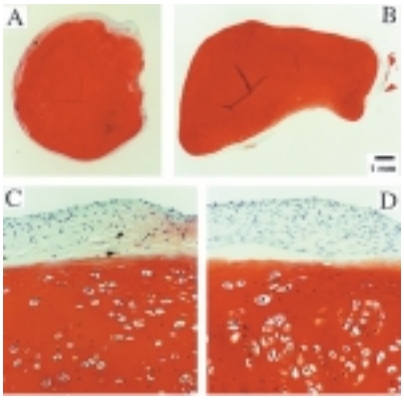
Combustion synthesis, or self-propagating high temperature synthesis has been investigated as a means of synthesizing a wide range of advanced materials, i.e. ceramics, intermetallics, metal matrix and ceramic matrix composites. Recent results show that these advanced materials can be easily formed, and the porosity can be controlled in the range of what is required for bone replacement. Similarly, rapid energy liberation by chemical reactions between atoms, atomic particles, and molecules have been observed and analyzed in combustion studies. In cooperation with the Russians, behavior of these reactions was studied in spaceflight aboard Mir, and on the ground at the Russian Keldysh Research Center and the NASA Johnson Space Center (JSC) White Sands Test Facility. Selected plastic materials were tested and comparisons made between normal and microgravity behavior for flammability, heat release, thermal properties, and combustion products (species). These data have been included in a spacecraft fire safety database crucial for successful engineering design of spacecraft and spaceflight hardware. Final reports by the Russian Center and the White Sands Test Facility presented the results of flammability measurements on the ground for the test materials and proposed a simple model to predict the minimum airflow for flame propagation.

The Coarsening in Solid-Liquid Mixture Experiment continued evaluation of previous flight data, which reinforced theories extending the well known "zero-volume fraction" theory of coarsening to the finite volume cases. These new data and theories are of great interest to manufacturers and users of high temperature materials. Use of the older formulae leads to erroneous results. Convection has previously been believed to be insignificant during crystal growth of ZnSe and related ternary compound semiconductors by using low vapor pressure Physical Vapor Transport techniques. Theoretical modeling, backed up by experimental results, has proven this premise to be incorrect.

Exciting fundamental research results were obtained from fluid physics experiments that were conducted on MIR. In the experiment "Growth and Morphology of Supercritical Fluids", led by a US/French team of scientists, it was observed that in a fluid consisting of liquid and gas phases on the verge of a transition, the gas temperature can exceed that of its surrounding heat source, a condition known as local overheating. This counter intuitive effect was predicted theoretically a decade ago and demonstrates the complex nature of heat transfer in fluids. It is a significant milestone in our understanding of phenomena such as boiling of fluids and heat transfer in gas-liquid systems.

Technology research in fundamental physics with the magneto optical trap feasibility ground demonstration was successfully completed. This technology will enable significant increases in the accuracy of timekeeping and more generally enable a broad range of general relativity experiments utilizing the microgravity environment. Refinements of this technology will be incorporated in several fundamental physics experiments that have been approved for flight on the ISS in the upcoming years.

Protein Crystallization research results from the Microgravity Science Laboratory (MSL) and MSL-Reflight Spacelab missions during FY2000 found that calcium binding proteins grown on orbit diffracted to a 0.9 Angstrom resolution. This is one of the higher resolutions ever achieved of a large biological macromolecule. Calcium binding proteins are important in regulating Calcium and Magnesium ions involved in signaling within the nervous system.



Engineered cartilage samples grown as part of Freed's earlier research with Bioreactor aboard Mir. Photos: Proceedings of the *National Academy of Sciences*

During FY 2000, microgravity research conducted broad, productive, Earth-based and space-based research that included new genes being expressed under microgravity conditions. This research

reveals that the microgravity environment of space fundamentally affects cellular processes and alters gene expression and represents the first application of recently developed gene array techniques to understand changes in cellular function in space. An agreement was signed with the first major private investor in cellular science, Fisk Ventures, which will use the NASA bioreactor as the basis for research and commercial development on the ground as well as in space.

Additionally for the first time 3-D tissue has been grown in microgravity on microcarrier or bioactive materials.

Flight Hardware Development

Significant progress has been made in the development of microgravity space flight hardware for use aboard the ISS. The Low Temperature Microgravity Physics Facility (LTMPF) made significant progress in developing a viable system design. LTMPF is the first U.S. payload scheduled to attach to the Japanese Experiment Module-Exposed Facility (JEM-EF).

The development of the first rack (MSRR-1) of the Materials Science Research Facility (MSRF) is progressing on schedule. Major components have completed the Critical Design Review (CDR) phase and international partner participation continues to stay on schedule.

The Fluids and Combustion Facility (FCF), Combustion Integrated Rack (CIR), and Fluids Integrated Rack (FIR) have progressed through the system development phase and continue to be on schedule for FY04 launch. The CIR completed its initial Preliminary Design Review (PDR) mid year

The Microgravity Glovebox (MSG) Training Unit was delivered to the JSC in August of 2000. The Training unit has completed checkout and is ready for crew training.

FY 2000 Microgravity Metrics and Performance

Support at least 425 research investigations.

The Microgravity Research Program funded 550 research investigations.

Support at least 12 Science Concept Reviews (SCR) and 20 Requirements Definition Reviews (RDR).

The program conducted 13 Science Concept Reviews (SCR) and two Requirements Definition Reviews (RDR).

Conduct research on at least 7 parabolic aircraft flight campaigns for selected science and engineering data and two suborbital rocket flights.

The program provided 11 parabolic flights and funded 2 suborbital flights; Spread Across Liquids (SAL-6) and Pool Boiling Experiment (PBE) with SAMS FF.

Conduct radiation shielding workshop to evaluate and prioritize materials candidates based on established performance criteria.

Microgravity Science and Applications Department (MSAD) co-sponsored Radiation Shielding Materials Workshop with University of California at Berkley in August 2000 and a workshop entitled Revolutionary Concepts of Radiation Shielding for Human Space Exploration at MSFC in September 2000.

Launch one Spread Across Liquids (SAL) campaign and one Extensional Rheology Experiment (ERE).

The 7th flight of the Spread Across Liquids (SAL) combustion investigation was delayed to February 2001 due to resolution of hardware problems that occurred during testing. One Extensional Rheology Experiment (ERE) fluids investigation flight occurred July 6, 2000; however, a subsystem failure caused loss of science data below minimum requirements. An investigation was conducted to determine the cause of failure.

Conduct an In-Situ Resource Utilization (ISRU) Workshop to evaluate and prioritize processing issues to be resolved by materials science research based on established performance criteria.

The ISRU workshop was held in Huntsville, Alabama on June 6, 2000 in conjunction with the Materials Science Conference.

Conduct requirements definition for granular flows, fluids, and dust management experiment.

MARS experiment was redefined and the program is awaiting further direction for this effort.

Issue STS–95 Mission Report.

Final Mission report was issued in January 2000 and all data returned to the companies or academic institutes sponsoring the projects.

Microgravity Science and Applications

The Microgravity Science and Applications Department (MSAD) within the Science Directorate at the Marshall Space Flight Center is responsible for implementing the Material Science, Structural Biology, and Glovebox programs for NASA. To implement the programs, Marshall Space Flight Center has a unique team of scientists, engineers, and managers teamed with industry, academia, and international individuals and organizations to establish, perform, and maintain world-class research in those fields. MSAD is also responsible for providing Glovebox facilities on the Shuttle and *ISS* for the purpose of supporting low-cost and fast-track investigations from all disciplines of the NASA Microgravity Program. MSAD is responsible for the financial and managerial administration of all selected Material Science and Structural Biology investigations, assistance in the definition of focused science objectives, access to ground and flight facilities and carriers, definition and development of new enabling research technology, definition and development of scientific apparatus and facilities, mission operations support, and transfer of the accumulated microgravity database.

MSAD FY 2000 Accomplishments and Highlights

Biotechnology Discipline

The Biotechnology Discipline was restructured during FY 2000 to implement a series of recommendations provided by a National Research Council (NRC) report released in March 2000. Based on a key NRC recommendation, the Structural Biology Initiative was created. This initiative is focused on clearly demonstrating the value of low gravity research to the structural biology scientific and commercial community. This initiative includes research on several high profile, important biological molecules. An additional focus, again spurred on by the NRC recommendations, is to dramatically shorten the process of getting investigators from idea to data, with the goal of approaching the speed of ground research. To execute this new initiative, four main activities were performed: Definition of an Interative Biological Crystallization (IBC) capability; review of the X-ray Crystallography Facility (XCF) capability; establishment of an Associate Investigator program; and creation of a new NASA Research Announcement (NRA). The IBC project is important in implementing the NRC recommendations because it will greatly simplify and speed the process for conducting biotechnology experiments of the *ISS*. When fully developed, the time required to perform a single repetitive experiment will be reduced from 6 months to 2 weeks. IBC will mostly automate the process for mixing, growing, and studying structural biology samples on the *ISS*. The review of the XCF capability pointed to a requirement for cryopreservation of completed experiment samples for return to Earth. This will preserve the results for study in the highest-powered X-ray generators in the world. The establishment of the Associate Investigator program essentially establishes the *ISS* as a national resource for any investigator in the biological crystallization community. During the creation of the new Biotechnology NRA, several new fields of study were opened for low gravity research including biological nanotechnology, structural

Enhanced Gaseous Nitrogen Dewar and its associated electronics box, as stowed in the Russian FGB Module aboard the International Space Station. The dewar is contained within the quilted Nomex flight bag and the electronics box is below, inside its protective foam enclosure.

biology, and biomaterials. The Enhanced Gaseous Nitrogen (EGN) Dewar was launched on STS 106 in September 2000 and spent 46 days in microgravity. From the Shuttle, the experiment was transferred to the *ISS* making it the first science payload on the *ISS*. EGN is a biotechnology experiment managed at MSFC that contained 473 samples. In addition to scientific research, this payload contained samples provided by middle school and high school students from four states. These students, working with the Principal Investigator, Dr. Alex McPherson, earned their way aboard the flight by outstanding work in a series of biochemistry workshops and classroom activities. This was the first flight of a pilot program intended to excite and teach students about science and engineering. This payload went from identification of the flight opportunity, through the integration process, to launch in under eight months.

The Structural Biology program also flew 504 samples on STS-101 in May 2000. Although the results of that flight are not yet determined, results from previous flights were completed in 2000. As an example, research results are continuing to be announced and published from experiments flown during the STS-95 mission (October 1998). They include: Crystals of NAD synthetase grown during the STS-95 mission diffracted to 0.9 Angstrom resolution, indicating crystals of exceptional quality. This resolution allows even hydrogen, the smallest atoms, to be found in the molecular structure. The protein is vital to the life cycle of all bacteria: Crystals of the enzymes RNAse P and 8-oxodGTPAse grown, diffracted to a better resolution than had been achieved previously. The enzymes regulate RNA production and repair of DNA respectively.

Approximately 200 peer-reviewed journal articles and presentations were generated from researchers in the MSFC Biotechnology Program, and some were presented at national and international conferences and university seminars during FY 2000. Additionally, several journal cover articles were generated bringing the total of cover articles from the program to over 20. Those articles, in the past, have included being on the cover of such prestigious journals as Science and Nature.

Material Science Discipline

During FY 2000 the Material Science discipline implemented over 60 grants and contracts from 1998 National Research Announcements (NRA) awards. Overall, some 163 Principal Investigator and Co-Investigators now participate in the Material Science program. A Microgravity Material Science Conference conducted by the program this year attracted 325 attendees from around the world. The program conducted five Science Concept Reviews (SCRs) during FY 2000 along with several major reviews involving the Material Science Research Facility (MSRF). MSRF is a joint research effort being conducted with European Space Agency (ESA) to develop Material Science Lab (MSL) as an EM (Experiment Module) for the first MSRF rack. Numerous payloads are currently under development within the program with flights on the *ISS* or Shuttle scheduled to begin in FY 2002 and continuing throughout the life of the *ISS*. Two KC-135 flights were made during FY 2000 as risk mitigations for planned experiments by Dr. August Witt's of the Massachusetts Institute of Technology and Dr. John Pojman of the University of Southern Mississippi.

First Material Science Research Facility Rack

Glovebox Discipline

The Glovebox Discipline received the Microgravity Science Glovebox (MSG) Training Unit from ESA during FY 2000. The unit has been verified and is being utilized at the Johnson Space Center for training the *ISS* crews in anticipation of delivery of the Flight Unit to the Station in FY 2002. The program also provided guidance and assistance to the several investigation teams who are scheduled to conduct experiments on increments 4 and 5. This included providing engineering guidance for interfacing experiments to the MSG, supporting preliminary testing of experiment assemblies in the MSFC MSG Ground Unit, and assisting with the development of on-orbit flight procedures. MSFC engineers also worked closely with the ESA in coordinating the resolution of engineering issues between the MSG manufacturing and *ISS* design requirement, and in the detailed planning of the testing of the Flight Unit prior to launch. The MSFC-developed Glovebox Integrated

Microgravity Isolation Technology (g-LIMIT) experiment completed its design phase during FY 2000 and began fabrication and assembly for flight on *ISS* increment 4 where it will be operated to protect sensitive experiments from low-level vibrations. Detailed test plans were developed and coordinated between the European Space Agency, Marshall Space Flight Center, Kennedy Space Center, and Johnson Space Center for the acceptance and verification testing of the MSG Flight Unit upon its delivery to Kennedy Space Center. The actual delivery was rescheduled to late in FY 2001 for flight to the *ISS* in FY 2002.

FY 2000 Microgravity Science and Applications Metrics and Performance

Perform verification testing and conduct acceptance reviews on microgravity science Glovebox in preparation for turnover to ISS for integration

The MSG trainer was delivered by ESA to NASA. The MSG trainer is functional and is available for crew training. The flight unit was not received from ESA during FY 2000. The Marshall Space Flight Center Glovebox team is prepared to conduct verification testing and acceptance testing of this hardware once it is received.

Initiate flight and ground investigation grants for 98 Material Science NASA Research Announcements.

All Material Science grants and contracts from the 1998 National Research Award (over 60) were implemented in FY2000.

The purpose of the Microgravity Glovebox Flight program is to provide a sealed and ancillary equipment and services for performing crew-operated and or teleoperated investigators which require isolation from the vehicle environment.

Space Product Development

The commercial development of space is one of the greatest opportunities facing America. It is the growth of business into space that will bring the benefits of space down to Earth and enrich the everyday lives of all Americans. To meet the charges and goals in its charter and strategic plan, NASA is encouraging businesses to seize this opportunity through the Space Product Development Program and its Commercial Space Centers (CSCs), to help ensure the continued economic growth of the U.S. and to bring the opportunities for new advances, technological understanding, products, and jobs to the public. Each CSC is a nonprofit consortium of commercial, academic, and governmental entities. The CSCs and their partners pursue product-oriented research in three major disciplines: Materials Research & Development, Biotechnology, and Agribusiness.

FY 2000 proved to be an outstanding year for the program. While flight opportunities were reduced, preparations for upcoming opportunities including STS-107 and the International Space Station are well underway and new flight opportunities are being actively sought. Efforts to increase the number of Industry Partners continued and strong success was reported through combined outreach efforts at more than 10 industry trade shows. Public and other targeted outreach activities were increased, with the World Wide Web resulting in a number of successful outreach activities. Ground and flight-based research resulted in a number of successful research efforts and new products. Specific examples include:

BioServe reached a long-term agreement with Bristol-Myers Squibb (BMS) to continue collaboration on a research project investigating ways for improving the efficiency of the microbial fermentation processes used in antibiotic production. Preliminary research conducted in microgravity has demonstrated up to a 200% increase in the fermentation process when compared to ground controls. BioServe and BMS are continuing this investigation and will fly further experiments on their first ISS flight scheduled to launch in April of 2001. This research could lead to methods for increasing the efficiency of antibiotic production here on Earth and result in significant cost savings for the American consumer.

A new fragrance that makes use of traditional Japanese scents designed to help impart a feeling of well-being and peace of mind is also making use of a totally new and truly out-of-this-world fragrance ingredient. Zen, a perfume developed by Shiseido in collaboration with International Flavors and Fragrances, Inc. (IFF), introduces a "space rose" note based on research conducted aboard NASA's STS-95 mission by IFF. The space rose note is part of the Zen fragrance's center, or middle "note," designed to bring to mind silence and nature. "The development of this entirely new and unique space rose note and its first commercial use in a fine fragrance sets a precedent in the fragrance industry and opens the door to the discovery of similar unknown aroma molecules," said Richard A. Goldstein, International Flavors & Fragrances' Chairman and Chief Executive Officer.

International Flavors and Fragrances Inc., is a company that creates and manufactures flavors, fragrances and aroma chemicals. The Overnight Scentsation rose plant was housed aboard NASA's shuttle flight STS–95 in a specially-designed structure under ultraviolet lights. The flowering plant was brought to Cape Canaveral from its home at IFF's greenhouse in Union Beach, New Jersey.

Researchers in the Flame Synthesis of Ceramic Powders project at the Center for Commercial Applications of Combustion in Space succeeded in calibrating the cutting-edge

laser diagnostic system that forms the backbone of their experimental apparatus, enabling them to see for the first time the very beginning stages of nucleation and formation of particulate in gas flames. Ceramic powders are used in a variety of applications, from coatings on machine tools to electronics.

Wound care research continued with Visteon Corporation who contacted ProVision Technologies to discuss the use of hyperspectral imaging to help in the evaluation and treatment of burn victims. An initial assessment was made, in conjunction with Children's Hospital of Michigan in Detroit, and the initial results were encouraging. Analysis of the data indicates a strong correlation between image maps of the burn, percent of body burned, and actual burn severity. There is also potential for using hyperspectral imaging to monitor, on a daily basis, the burn wound healing process.

Metal Oxide Technologies is commercializing a new technology for the use of High-Temperature Superconducting (HTS) wires using oxide thin films, developed by the Space Vacuum Epitaxy Center, a Commercial Space Center. This technology has been licensed and a pilot plant for producing HTS wires for use in power line transformers is expected to be operational by 2001.

FY 2000 Space Product Development Metrics and Performance

Publish modified Selection Criteria (Flight) after approval

Completed. Commercial Selection Criteria have been modified to explicitly require a plan for meeting safety reviews.

Review and make recommendations on establishment of additional Commercial Space Centers

Completed. Promising areas in the fields of polymers, photonics, and robotics have been evaluated by the SPD office. Preliminary data supports creation of a new CSC in the broad area of robotics, simulations, virtual reality, and or controls.

Complete all actions relating to the NAPA report

Completed. The remaining actions relating to the NAPA report were:

- Complete probationary period of the two affected CSC's. Done.

Complete the transition/phase-out of the NASA commercial projects. Aerogel project was phased-out. Gas permeable polymer materials is on hold pending industry affiliate reorganization. All other projects have been transitioned.

Provide policies and guidance to support the CSC's with short-notice flight opportunities

Completed. The flight assignment working group planning manifest was revised to accommodate overflow of research mission payloads. Commercial Space Centers were advised to maintain flight readiness for those payloads which they need immediate flight for.

Dr. Harry Whelan of the Children's Hospital of Wisconsin, Medical College of Wisconsin, Milwaukee, tests special lighting technology originally developed for NASA space-based plant growth experiments and now used for treatment of cancerous tumors. The Light Emitting Diode(LED) research project is funded by a NASA Small Business Innovative Research program grant. Whelan is a native of Milwaukee. (Photo by Emmett Given, NASA Marshall Space Flight Center)

Space Optics Manufacturing Technology

Goal: Lead the Agency in the development of advanced technologies and manufacturing capabilities essential to large aperture, lightweight space optics for use in achieving the mission goals of NASA's strategic enterprises.

The Space Optics Manufacturing Technology Center (SOMTC) was created in the 1999 MSFC reorganization as an integral part of the Science Directorate. SOMTC's purpose is to become a national focal point for developing advanced technologies supportive of large, lightweight, and low-cost optics for space use. This requires breaking old paradigms and finding innovative applications of promising technologies.

NGST

The history of astronomical optical systems has shown a continuous drive towards lighter optical elements. The primary mirror in the ground-based Hale telescope at Mt. Palomar (using 1947 technology) weighs roughly 550 Kg/m^2. The Hubble Space Telescope primary (with 1980's technology) weighs about 150 Kg/m^2. MSFC is supporting Goddard Space Flight Center by leading the development of ultra light optics for the Next Generation Space Telescope (NGST). The design goal for the NGST mirror, scheduled to fly around 2008, is 15 Kg/m^2. MSFC is participating in the management of three major mirror development programs: the New Mirror System Demonstrator (NMSD), the Small Beryllium Mirror Demonstrator (SBMD), and the Advanced Mirror System Demonstrator (AMSD). Several different mirror technologies ranging from 0.5 meter to 2.0 meters in diameter are being developed that meet the NGST weight goal. The AMSD program is unique in that funding is being provided by multiple agencies including NASA and the United States Air Force.

CXM

SOMTC is a key resource in mirror technology support to Goddard on the next generation x-ray mission called Constellation X. This mission will be a follow-on to the recently launched Chandra Observatory. Constellation X is planned for mission new start around 2005 and will require even lighter weight x-ray optics than previously developed.

Advanced light weight composite material mirror testing for NGST.

During 1999, SOMTC fabricated the pathfinder shell for this mission with a thickness of 0.25 millimeters. In 2000 SOMTC fabricated a pathfinder x-ray mirror shell with a wall thickness of only 0.15 mm. This shell satisfies the weight requirement for the Constellation X mission. This pathfinder x-ray shell was 6 times lighter than previous shells at 0.5 meter diameter. SOMTC and its partners are on track to generate further improvements in increased angular resolution to meet the mission requirements.

Microgravity

An 8 inch in diameter lamellar grating was designed and fabricated this year. The grating was designed to work in a Littrow configuration for a coherent lidar beam steering application. The goal of the research was to maintain circular polarization and diffraction efficiency using numerical Rigorous Coupled Wave Analysis design techniques and a deep etch fabrication approach at Lawrence Livermore National Laboratory.

Research

Areas of research expertise at SOMTC include: optical physics, photonics, electro-optics, laser systems, diamond turning and precision engineering of optical surfaces, test and analysis of optical system stray light performance, test and analysis of x-ray optical systems, and developing unique and innovative methods for optical fabrication, testing, and coating.

Research efforts in the area of laser physics led to the develop

ment of a solid-state Rodamine-impregnated polymer used as a lasing gain medium. A master oscillator and light amplifier were demonstrated using this new material. Applications for use range from power beaming and energy transfer to new methods for in-space propulsion.

In collaboration with the University of Alabama in Huntsville, SOMTC designed and specified the fabrication of the first Adjustable Focus Optical Correction Lens (AFOCL). The AFOCL is an active optical component used for wavefront control. The AFOCL is composed of a solid state lead lanthanum-modified zirconate titanate (PLZT) ferroelectric ceramic element that performs variable focusing and integrated wavefront correction by virtue of the ferroelectric properties of the material. This innovative device offers the potential to replace the more massive solid refractive lens systems (e.g. zoom lenses, telescopes, and optical sensors) and their mechanical focusing stages with stationary, low-mass, rugged, thin optical elements that produce as good or better wavefront quality as the solid refractive lenses they replace. Testing of a fabricated AFOCL sample is scheduled to begin in early FY2001.

SOMTC conducts research efforts in large area fresnel lens development. Fresnel lenses consist of a series of concentric annular rings with a specific prescribed shape that allows all rings to act as a single lens with a common focus. The rings all lie in a common plane, making a fresnel lens extremely flat as compared to a common refractive lens. Fresnel lens research efforts contribute to three different concepts currently being studied for use in detecting high-energy gamma rays and their interaction with the upper atmosphere. The Extreme Universe Space Observatory (EUSO) is a European Space Agency (ESA) proposal to fly a 2.5-meter telescope using two fresnel lenses and attach it to the exterior of the ESA Columbus module on the International Space Station. Prototypes for the EUSO project have been manufactured and a decision on funding for EUSO is scheduled for early 2001. The Orbiting Wide-angle Lens (OWL) concept involves a telescope up to 10 meters that will be a free flying satellite. OWL is a NASA project that is being considered for a 2010 launch. The third activity is a National Science Foundation (NSF) Physics Frontier Center (PFC) proposal "Science and Development of High Energy Particle Detectors Exploiting Atmospheric Phenomena" which will include a three element fresnel telescope five meters in diameter. SOMTC intends to provide fresnel lens expertise to each of these research endeavours.

Constellation-X Replicated Mirror Shell.

SOMTC has entered into a collaborative effort with the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL) to develop high-efficiency diffraction gratings (called grisms) for space-based applications. Potential applications include grisms in MgF_2 and/or lithium flouride for high-efficiency, low-dispersion far ultraviolet imaging spectroscopy; grisms tailored for broad band Earth science remote sensing spectrographs; grisms in infrared materials such as silicon or germanium for infrared spectroscopy; and concave echelle gratings for high-spectral resolving power ultraviolet spectroscopy of the Earth's atmosphere and astronomical objects. For the research tasks at hand, grating design and final optical testing will occur at GSFC. Electron beam lithography will be the responsibility of JPL. Development of etching processes, including highly UV transmissive substrate materials, is the responsibility of

SOMTC. This will occur at a joint MSFC/U.S. Army AMCOM microfabrication facility on Redstone Arsenal in Alabama. The etching technology developments to be performed by SOMTC will provide new optical design freedoms leading to compact geometry and smaller and lighter weight optical systems.

Nonmechancial optical beam steering is being studied as a result of research in the area of electro-optical modulation of multilayered dielectric stacks. The beam steering is accomplished by passing optical signals through an array of micrometer-sized phase modulators. Each individual modulator is constructed using multilayered stacks of thin film dielectrics. The optical properties of the stack are influenced by the applied electric field or the injected current density, resulting in a controlled phase change of the propagating signal. Each modulator within the array is electronically set to provide a determined amount of phase adjustment to the transmitted optical signal. Diffractive interactions past the modulator array provide regions of constructive and destructive interference, causing most of the beam's energy to propagate in a direction that is at some angle to the array's normal axis.

Metrology

SOMTC is developing a center for calibration and metrology of large optical components and systems. It is a partner with the National Institute of Standards and Technology (NIST) in the area of large optics metrology. The facilities and expertise of SOMTC including optical fabrication, optical metrology, stray light scattering, and surface morphology are being applied to a number of NASA, Department of Defense, Department of Energy, National Oceanographic and Atmospheric Administration (NOAA), industry, and academic needs.

Active control mirror array.

FY 2000 Space Optics Manufacturing Technology Metrics and Performance

Conduct research and analysis in diffractive optics and coating applications.

Advance the test readiness list one level in optical beam steering

The optical phase modulators required for creating beam steering arrays have been designed and specified for fabrication by Wright-Patterson AFB. A sample has recently been fabricated and is currently undergoing laboratory characterization.

Demonstrate the fabrication of 8-inch diameter diffractive optics

This metric response is covered by the response to the 20-cm diffractive optic described below.

Demonstrate imaging performance of a .37 m fresnel lens

Funding retractions from Code S's Cross Enterprise Technology Development Program forced the fresnel lens development efforts to de-scope for FY 2000 anticipated accomplishments, resulting in schedule changes for metric milestones.

Produce solar concentrators with 50 percent higher flux levels to enable solar power systems with efficiencies > 40 percent.

Funding retractions from Code S's Cross Enterprise Technology Development Program forced the fresnel lens development efforts to de-scope FY 2000 anticipated accomplishments, resulting in schedule changes for metric milestones.

Investigate one new coating for x-ray mirror technology

Plasma sprayed vanasil (high silicon content aluminum alloy) is being investigated for mirror carrier shells. This material is 1/3 the density of nickel alloy materials, allowing increased thickness for greater rigidity with no increase in weight. Small shells have been fabricated in order to establish process parameters prior to scaling to .5-meter diameter.

Upon delivery, test the two NGST demonstration mirrors at cryogenic temperatures.

Two mirrors were tested. SBMD (Sub-Scale Beryllium Mirror Demonstrator) was cryo-tested three times. NMSC (NGST Mirror Systems Demonstrator) COI mirror was cryo-tested once.

Produce a 0.2 m diameter scanner with 80 percent efficiency for a 30-degree scan angle.

The design and fabrication of specialized 20 centimeter diameter plane transmission gratings in fused silica have been completed. Lamellar gratings have been designed for equal efficiency at either TE or TM polarization when used with 2 micron laser radiation at 15 degree incidence angle.

20 centimeter diameter transmission gratings for high efficiency diffraction at littrow angle for arbitrary polarization

The application task at hand is develop technologies that produce large aperture, lightweight, beam scanning optical elements for coherent laser radar. The requirements are unique and include maintenance of polarization, high diffraction efficiency at a deflection angle of 30 degrees, and less than tenth wave peak-to-valley aberration at use angle.

The grating design was performed with numerical rigorous coupled wave analysis techniques and a –1 diffraction order design efficiency of 80 percent for each polarization state is predicted. Following fabrication at Lawrence Livermore National Laboratory, which has the capacity to scale the grating fabrication process to 1 meter diameter, optical testing resulted in overall wavefront errors of 0.09 waves peak-to-valley, which is less than the goal of one tenth wave. Diffraction efficiencies were determined to be fairly well balanced between the TE and TM polarization modes, with –1 diffraction order efficiencies measured at 65 percent. The measured diffraction efficiencies are less than the design predictions due to fabrication issues; the target etch depth of 3.9 microns was not achieved due to erosion of the mask during long-etch processing. This is the problem to overcome in future efforts.

Implement processes at the XRCF to reduce the cost of optical systems testing by 10%.

We implemented a procedure to use minimal LN2 while performing a cryo-optical test. We tried various meth-

FY 2000 Space Optics Manufacturing Technology Metrics and Performance

ods and found we can operate the Instrument Chamber using only a small pump and minimal cold surfaces. Our savings in LN2 went from 14 GPM to 4 GPM for a savings of about $ 3000 per day. We also fully implemented our facility "out of spec" paging system which allows us to operate the facility at night and over weekends in an unmanned condition. Labor savings would be at least $1500 per day on the average. Our total test cost is running about $ 9000 per day. This results in a net savings of about 33 %.

Establish a customer satisfaction tracking program.

The tracking program was implemented and initially discovered communication issues between the SOMTC and some of its customers. These issues were quickly identified and corrected resulting is a high degree of customer satisfaction.

For Constellation-X, demonstrate resolution <= 10 arc seconds in replicated x-ray optics weighing <=1/3 the weight of XMM optics.

The measured low-energy resolution (half-power diameter) of Constellation-X optics tested in 2000 was approximately 50 arc-sec. 40 arc-sec of this was from figure error (non-zero residual stress from the electroforming process), and up to 30 arc-sec was from out-of-roundness due to support-induced deformations during bonding to test mount. These issues are being actively pursued. The weight goals were met.

Produce 0.5 m diameter normal incidence replicated optic with thickness variation less than 5 percent over the mirror surface.

Funding limitations resulted in an 8 month delay in establishing the new electroforming facility at Alabama A&M University required to develop these unique normal incidence optics. A new setup is currently under construction. Second generation mirrors will not be produced for several months. However, at that time the 5% metric should be met or exceeded.

Deploy and test and inductive edge sensor mirror alignment technology in a ground based observatory.

In progress. In October of 2000, MSFC and partner Blue Line Engineering installed 48 inductive edge sensors and supporting electronics and control system on the seven of the 91 segments in the primary mirror of the 9.2 meter Hobby Eberly Telescope in southwest Texas. Test indicates that the edge sensors are rugged (they survived a freak 30 year freeze shortly after installation) and accurate (demonstrating 17 nm RMS error).

Identify concepts and materials for 0.1 kg/m^2 ultra lightweight optical substrates.

Investigations are underway to develop candidate materials suitable for use as reflective and/or transmissive optical elements in the space environment. Concepts for deployment, mounting, and active control of such elements are also being developed.

Establish test-bed for image-based wavefront sensing and control system.

In progress. The systematic image-based optical alignment (SIBOA) tested achieved first light in April 1999 in room B143A of building 4487. Diffraction limited alignment of the seven segment array was first achieved in September 1999. Dr. Phillip Olivier of Mercer University, working in conjunction with MSFC researchers, completed the first simulations of a neural fuzzy logic controller for SIBOA in August 1999. The unscheduled move of the test bed to NSSTC has delayed closed loop operation with image-based algorithms.

Other Programmatic Assignments

The following is a brief summary of program-related assignments being implemented by MSFC for the NASA Enterprises and other Lead Centers.

International Space Station (ISS)

International Space Station

The *ISS* is a U.S.-led, international partnership involving much of the world's spacefaring community. In FY 2000 the *ISS* became operational, providing a home for continuous human presence in space. Marshall plays a major role in the development and operation of the *ISS*, from manufacturing and testing hardware to *ISS* research and science operations. Marshall's *ISS* responsibilities in FY 2000 included support through task agreements with the *ISS* Program Office at the Johnson Space Center. This support included development of regenerative life support systems for crew and research animals, and management oversight of two node elements, the multipurpose logistics module built by the Italian Space Agency, the Interim Control Module built by the Naval Research Laboratory, and the propulsion module being built by the Boeing Company. Marshall developed research facilities for the *ISS* which included the EXpediting the PRocess of Experiments to Space Station (EXPRESS) rack and other payload support equipment. Marshall also supported the program through the integration of Spacelab pallets and support equipment for *ISS* assembly, and the environmental qualification testing of major *ISS* elements and systems. Marshall performs all preflight dynamic and static structural testing of U.S. *ISS* elements and qualification testing of some *ISS* components.

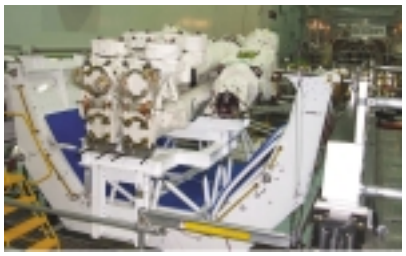
Marshall is also responsible for management, integration, and execution of payload operations and utilization activities onboard the *ISS*. The Payload Operations Center (POC) located at MSFC is the *ISS* Program focal point for payload operations. MSFC controllers staff the facility and interact with the worldwide scientific research community to plan and conduct payload operations on board the *ISS*. Payload operations training is a joint effort between MSFC and JSC.

ISS configuration in 2000.

MSFC supports the *ISS* assembly by providing the Payload Carriers Program (PCP) pallets to transport the *ISS* hardware to orbit from the shuttle bay. MSFC provides the certification for the cargo element launch configuration and the equipment to support the flight hardware. In October 2000, the first flight of a PCP pallet for the *ISS* program occurred on STS-92 for the 3A-assembly mission. The 3A mission successfully delivered the pressurized mating adapter (PMA) and the associated EVA toolboxes to the *ISS*. The mission was completed successfully and all mission objectives were met. The flight support equipment from flight 3A is now in storage and will be re-used for a later pallet carrier flight. This is a significant cost avoidance for the *ISS* program and allows multiple use of the flight support hardware.

Spacelab Pallet/PMA-3 for Flight 3A.

The next flight of a PCP pallet carrier will be the flight 6A-assembly mission. The cargo for the 6A mission is the Canadian Space Agency built space station remote manipulator system (SSRMS) arm. The 6A pallet will be the first pallet carrier to be removed from the shuttle bay and connected to the *ISS*. The SSRMS was assembled to the 6A pallet carrier and the critical match drilling operation to align the attachment bolts for the SSRMS to the pallet was



Pallet for *ISS* Flight 6A with Space Station Remote Manipulator System (SSRMS).

completed in August 2000.

MSFC was requested to build a new carrier system to take advantage of the available shuttle bay 13 resources. This carrier is designed to fit the narrow constraints of the bay 13 location and still provide approximately 4000 pounds of payload carrying capability. The carrier design is complete and will allow rapid turnaround and very late (launch on need) integration of hardware into the shuttle bay. The bay 13 carrier is being built from existing PCP inventory hardware that has not been fully utilized. This will provide a cost avoidance for the *ISS* program and a new use for the bay 13 of the shuttle. MSFC developed the shuttle to carrier interface and the mission integration process.

Marshall provided the mission integration and the design development oversight of the multi-purpose logistics module (MPLM). MSFC is responsible for the mission integration of the first mission use of the MPLM on the 5A.1 flight. MSFC provided the design oversight for the design and certification of the 3 MPLMs. The Final Acceptance Review of the third module from the Italian Space Agency occurred in 2000. MSFC led the design review and closeout of the hardware issues for all three modules. MSFC is providing the sustaining engineering oversight for the MPLM hardware. MSFC's efforts were critical to coordinate close out of the technical issues with the MPLM hardware and finalize the certification of the MPLMs for flight. MSFC coordinated and resolved design issues with Agenzia Spaziale Italiana (ASI), their contractor Alenia Spazio, the European Space Agency (ESA) and the *ISS* program, as well as the various NASA field centers involved.

Marshall provided preflight dynamic and static structural testing of the US *ISS* hardware elements and provided environmental qualification testing for *ISS* hardware items. MSFC provided a wide variety of testing, manufacturing support and engineering services to the *ISS* program. MSFC provided key technical specialists such as the electromagnetic compatibility (EMC) lead; the internal audio system lead; the atomic oxygen test lead; the industrial safety oversight for the *ISS* prime contractor Boeing; and the lead for lifting and transporting large *ISS* elements for Boeing. MSFC provided just in time manufacturing services to build miscellaneous hardware items to allow critical tests to be completed by Boeing. MSFC provided micrometeor and debris simulations and recommendations for survivability of the *ISS* hardware in the event the *ISS* is struck by a micrometeoroid or debris. MSFC designed and built a prototype for an EVA applied patch system to repair a pressurized *ISS* module while on orbit. MSFC provided material testing for flammability and toxic off-gases tests of *ISS* hardware. Marshall provided material design information through its material data base system and provided material certification for the use of hardware in the *ISS*. Marshall completed failure analysis of *ISS* hardware using the specialized testing available in its materials testing laboratory. MSFC provided life testing of the seals used in the joints of the *ISS* modules to monitor the long-term quality of the seals in a vacuum. As part of the *ISS* Sustaining Engineering effort, MSFC provided an engineering support room (ESR) to allow Boeing to perform real-time support for the on orbit integration of the *ISS*. *ISS* Sustaining Engineering support for berthing operations during on orbit integration was provided

Multi-Purpose Logistics Module (MPLM) in Alenia clean room.

by the contact dynamics simulation Six Degrees of Freedom (6DOF) in the Contact Dynamics Simulation Laboratory and by the Boeing operated Common Berthing Mechanism (CBM) mounted in the MSFC 20FT Vacuum Chamber.

Marshall is providing the technical management oversight of Nodes 2 and 3, which will be provided by the Italian Space Agency (ASI) through a bartered European Space Agency to NASA agreement. The purpose of both Node 2 and 3 is to act as the connecting elements for other station elements including the space station system utilities and to provide a safe pressurized passageway between other international elements. Both Node 2 and 3 utilities include commands and data flows, audio, video, electrical power, thermal and atmosphere controls, and water. Node 3 will uniquely provide the crew with a toilet and cleansing areas. The International Space Station common hardware and software components will be provided by NASA to Alenia Spazio for integration, test, and checkout into the Alenia designed, developed and tested modules, Node 2 and 3.

Progress continues to be made in both these elements. Node 2 is completing the design and development phase with plans for the Design Review #2 in early FY 2001. Node 2 initiated the ground processing activities in FY 2000. These activities will continue and increase at Kennedy Space Center until FY 2003. Node 3 completed Design Review #1, the first of two scheduled formal NASA design and development reviews. Per Assembly Sequence Revision F, Node 2 is scheduled for launch on 10A, October 2003 and Node 3 is scheduled for 20A just 23 months later.

Marshall is responsible for developing water recycling and oxygen generating systems for the Space Station's Environmental Controls and Life Support System (ECLSS). In 2000, the ECLSS team continued to make progress on the design and development of the major hardware components, with Critical Design Reviews completed for all major assemblies. An Interim Project Review for Integrated Racks was held in December 2000. Major procurements have been initiated and manufacturing has begun.

The ECLSS team also successfully delivered a number of critical system elements, including the Vapor Compression Distillation Flight Experiment (VCD FE) which is set for launch on STS-107 (currently scheduled for May of 2002). The VCD FE is a full-scale urine processor, which will be used to demonstrate in a microgravity environment the technology to be used in the Urine Processor Assembly (UPA). The UPA (to be integrated into Node 3) will provide the means to recycle crew urine into potable water, thus reducing significantly the amount of water that must be carried to the *ISS* via the Space Shuttle.

In addition, the Portable Fan Assembly (PFA) and Carbon-Dioxide Removal Kit (CRK), which will be used to enhance ventilation inside the *ISS* modules as needed for crew comfort and to minimize the potential of crew exposure to harmful gases during rack rotations, were delivered to the *ISS* in September 2000. The PFA/CRK combination provides removal of carbon dioxide from the environment in case of an emergency.

The Velocicalc Thermal Anemometer, a hand held device capable of determining air velocity, temperature, and relative humidity, was flown aboard the *ISS* on missions 2A.2a and 2A.2b. It is currently expected to fly again on missions 6A. The unit proved itself the first day aboard 2A.2a when Velocicalc readings indicated an anomaly in the newly installed *ISS* cabin air ducting. A video survey revealed that some of the ducting had been assembled incorrectly. The portability and accuracy of the Velocicalc allowed the crew to perform real-time tests and make real-time repairs.

Astronaut Ellen Ochoa works with the Volatile Removal Assembly Flight Experiment during the STS–96 mission. This hardware was successful in demonstrating technologies to be used in the Water Recovery System, which will recycle water for the *ISS*.

Marshall is responsible for producing all 13 of the Station's EXPRESS type racks, which make up nearly half the entire complement of payload racks aboard the Station. The EXPRESS racks are slated for use in government and commercial projects, including life science research and microgravity projects managed by Marshall and protein crystal studies by University of Alabama in Birmingham. The first racks will begin operation on *ISS* flights 5A.1 and 6A. Additionally, MSFC has leadership responsibility

for the Window Observational Research Facility (WORF) development and integration. Based on the EXPRESS rack design, the planned facility will support unprecedented Earth observation research. Flight of this rack is currently scheduled on Utilization Flight-1 (UF-1).

MSFC is tasked with overseeing all science operations aboard the *ISS*. To accomplish this complex mission, the *ISS* program commissioned Marshall to design, implement, and staff the *ISS* Payload Operations Center (POC), a 24-hour control facility coordinating all *ISS* science operations. This center is located within the walls of the multiprogram Huntsville Operations Support Center (HOSC), and will communicate with the *ISS* crew, researchers, and scientists around the world to enable the remote operation of onboard science payloads.

ISS payload operations includes end-to-end planning, training, and flying of science missions on the *ISS*. NASA has the dual role of (1) leading all agencies of the *ISS* international partner nations in the integration of Space Station payload operations, and (2) managing the activity of U.S. science operations. MSFC's POC Cadre team has been delegated the integration responsibility over these areas, with a charter to ensure safety and to promote mission success and the efficient use of the *ISS* crew and resources. For the U.S. payloads, the MSFC team also develops and manages the astronaut payload training activities at the Payload Training Center in Houston. Throughout the year 2000, the POC Cadre teams have developed procedures and processes for planning and training their own team and the rest

ISS Payload Operations Center (POC) at MSFC.

of the payload and science community. The successful execution of those processes was verified in 2000 by the first successful *ISS* simulations, including joint simulations with Mission Control Center (MCC)-Houston and MCC-Moscow.

To provide the underlying infrastructure for all these capabilities, the Ground Systems Department development team is developing new voice, video and data system capabilities for the POC within the HOSC facility and at other *ISS* program sites. The development team has responded to the dynamic technology environment by developing new approaches as user expectations changed (web-based processes) and as the commercial environment changed (microprocessor power and marketplace direction). These new approaches serve both the operations and integration functionality of the real-time control team in the HOSC, and the high-bandwidth data distribution needs of the science users at remote locations. And of course, these data and communications systems support a more complex interaction with international control centers than has ever been attempted in any previous space program. Currently, the core delivery of the basic *ISS* payload data systems is complete and has been deployed in the HOSC and at KSC, and it has successfully supported *ISS* tests, simulations and operations. In 2000, the team made many incremental deliveries of the HOSC core systems, including the critical delivery to support the start of *ISS* payload operations on *ISS* flight 5A.1. As *ISS* payload operations ramps up into full swing, further deliveries will augment the core capabilities with *ISS*-unique functions, especially in support of the *ISS* remote operations concept.

Earlier in the *ISS* program, the POC Cadre teams developed that remote operations concept, which puts a total emphasis on teleoperations, enabling each scientist at their remote location to monitor and control the science payloads from their home base. The systems development teams provided the necessary system infrastructure functionality within the HOSC, and also orchestrated the overall architecture, which provides the remote user with his connectivity, and most of his local data processing needs. A Marshall Civil Service team is developing and distributing the Telescience Resource Kit (TReK) solution that pro-

vides end-user command and telemetry software functions for a PC-based platform. The remote scientists can use TReK at their home bases for most command, telemetry and other functions, maximizing their integration with the POC operation, but with minimum effort or cost on their part. Also, the MSFC and contractor team is developing low-cost innovative solutions for video distribution and internet voice conferencing as part of an integrated remote science operations architecture. By the end of 2000, TReK operational software was released and in the hands of 70 future *ISS* experimenters. The internet voice conferencing system was developed during 2000, partially with a commercial internet voice software company who will augment their commercial product for the unique needs of the space program. That system goes operational in early 2001.

The Shuttle program flies more safely because of the engineering support area that is provided by the HOSC, and it is energized to monitor every launch from MSFC. Also, the HOSC performed payload operations for the Shuttle Radar Topography Mission in February 2000.

The Interim Control Module (ICM) was manifested for a February 2001 launch aboard the space shuttle. ICM was on-track to be shipped to the Kennedy Space Center in September 2000 to begin launch processing and integration into the shuttle. With the successful launch and on-orbit activation of the Russian Service Module, work was begun to reconfigure the ICM for an XA.1 mission and launch no earlier than February 2003.

FY 2000 International Space Station Metrics and Performance

Provide carrier integration on schedule for ISS Flight 3A in 1st quarter of FY 2000.

Carrier integration was completed on schedule to meet the revised *ISS* program schedule for Flight 3A in October 2000.

Provide carrier integration on schedule for ISS Flight 6A in 4th quarter of FY 2000.

Carrier integration is being completed on schedule to meet the revised *ISS* program schedule for Flight 6A in FY2001.

Integrate the first MPLM in preparation for flight 5A.1, 3rd quarter of FY 2000.

MPLM integration has been completed on schedule to meet the revised *ISS* program schedule for Flight 5A.1 in FY2001.

Conduct integrated payload operation on ISS beginning with Flight 4A in FY 2000.

Integrated Payload Operations began with *ISS* Flight 4A as planned and has been ongoing since that time.

Conduct operational readiness reviews in FY 2000.

Operational Readiness Reviews for FY 2000 were successfully completed as planned.

Complete development and integration of EXPRESS racks in accordance with flight schedules beginning in FY 2000.

Rack deliveries are meeting flight production schedules. Four racks are currently at KSC for ground processing.

Complete preparation for launch of the first rack of the Human Research Facility on Flight 5A.1.

The HRF rack successfully completed payload integration and ground processing activities. The rack is currently on board the *ISS*.

Demonstrate the capability for principal investigators to conduct remote operations support of ISS payloads in FY 2000.

Joint Integrated Simulations were conducted between MSFC and principal investigators at their facilities. These simulations demonstrate the remote operations capability required for flight.

Complete ISS Propulsion Module CDR in FY 2000.

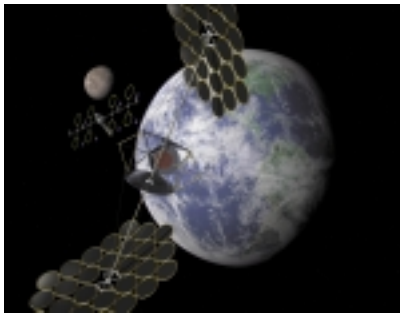
The *ISS* Propulsion Module project was canceled in early FY 2001 following the successful launch and on-orbit activation of the Russian Service Module and revised *ISS* Program requirements.

Prepare ISS Interim Control Module for late FY 2000 availability.

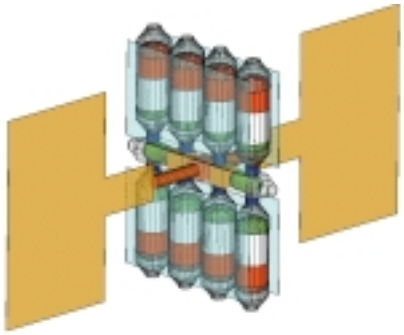
The *ISS* Interim Control Module (ICM) was on schedule for shipment to KSC in September 2000. With the successful launch and on-orbit activation of the Russian Service Module, work was begun to reconfigure the ICM for an XA.1 mission and launch no earlier than February 2003.

Advanced Projects

In response to NASA's goal to expand the frontier by investing in enabling high-leverage exploration technologies, Marshall's Advanced Projects Office managed the Space Solar Power (SSP) Exploratory Research and Technology (SERT) activity. This activity included analysis of systems concepts to identify viable approaches to SSP for planetary surface and space applications. Additional related activities included work on propellant depot concepts powered by advanced SSP systems to support transportation concepts for human missions beyond low-Earth-orbit (LEO).



Space Solar Power satellite concept for beaming energy to Earth.



Propellant Depot concept powered by advanced space solar power systems.

FY 2000 Advanced Projects Metrics and Performance

Publish a final report on the SERT study. Material within the report will include concept analysis, technology roadmaps and recommendations on near-term technology development and demonstrations.

During FY2000, Congress mandated that NASA continue the Space Solar Power (SSP) activities. The SSP Exploratory Research and Technology (SERT) Study management team applied the funding to extending the SERT activities through FY2000. Additional contracts were selected from the 1999 SERT NASA Research Announcement (NRA) and several ongoing contracts were extended. Presently, many of the contracts are concluding and the management team is receiving final reports. Material from SERT subsystem and system engineering teams, workshops, and Technical Interchange Meetings (TIM) has been consolidated and indexed in an internet accessible information management system known as the Virtual Research Center (VRC). Current efforts include developing themes and an outline for the final report and identifying contributors to write specific sections of the report.

Demonstrate SSP technologies in solar power generation (SPG), power management and distribution (PMAD), and wireless power transmission (WPT)

Technology demonstrations were conducted for the SSP community and the general public. Solar Power Generation, Wireless Power Transmission (WPT), and Power Management and Distribution were demonstrated through laboratory experiments, outdoor ground demonstrations, and indoor demonstrations at Technical Interchange Meetings (TIM). During the MSFC Open House in the summer of 2000, hundreds of people saw prototypes of a stretched lens array and witnessed or participated in demonstrations of a teleoperated rover. The rover is part of a ground demonstration of a future lunar rover powered by microwave energy. Three TIMs were held during the SERT study where demonstrations of WPT, robotics, and deployable structures were demonstrated.

Chandra X-Ray Observatory (CXO)

Chandra X-Ray Observatory

NASA's Chandra X-ray Observatory continues in its second year in orbit with an impressive list of scientific firsts. Through Chandra's unique X-ray vision scientists have seen for the first time the full impact of a blast wave from an exploding star, a flare from a brown dwarf, a small galaxy being cannibalized by a larger one, and have discovered an iron line emission in the afterglow of a gamma-ray burst.

Chandra has detected a faint X-ray source in the Milky Way galaxy, which may be the long-sought X-ray emission from the known massive black hole at the galaxy's center. Further out, the observatory captured an image that revealed gas funneling into a much cooler than expected massive black hole in the heart of a galaxy, two million light years from our own Milky Way.

Perhaps one of Chandra's greatest contributions to X-ray astronomy is the resolution of the X-ray background, a glow throughout the universe whose source or sources are unknown. Astronomers are now pinpointing the various sources of the X-ray glow because Chandra has resolution eight times better than that of previous X-ray telescopes, and is able to detect sources more than 20 times fainter.

Three high school students, using data from Chandra and the National Science Foundation (NSF) won first place in the Siemens-Westinghouse Science and Technology Competition in Washington, DC. The team award was based on their discovery of the first evidence of a neutron star in the nearby supernova remnant IC443.

While reaping numerous scientific accomplishments, the Chandra team has been recognized for its engineering feats as well. The honors include being selected as the winner of the Editor's Choice category of the 2000 Discover Magazine Awards for Technological Innovation, the AIAA 2000 Space Systems Award, and the National Air and Space Museum's Trophy recognizing outstanding achievement in scientific or technological endeavors relating to air and space.

Chandra is the third in NASA's family of great observatories, complementing the Hubble Space Telescope and the Compton Gamma Ray Observatory. Chandra was launched in July 1999.

The Chandra Program Office in the MSFC's Flight Projects Directorate manages the program for the NASA HQ's Office of Space Science. The Technical Support Team members from the Engineering Directorate and the Space Transportation Directorate provide subsystem performance analyses as well as the expert support for critical operational activities such as solar eclipses and safe mode recovery events. MSFC's Science Directorate provides the scientific management and oversight of the Chandra observing program.

TRW Space and Electronics Group, Redondo Beach, CA, was the development prime contractor. Using glass purchased from Schott Glaswerke, Mainz, Germany, the telescope's mirrors were built by Raytheon Optical Systems Inc., Danbury, CT, coated by Optical Coating Laboratory, Inc., Santa Rosa, CA, and assembled and inserted into the telescope portion of Chandra by Eastman Kodak Co., Rochester, NY.

The scientific instruments were supplied by collaborations led by Pennsylvania State University, University Park; Smithsonian Astrophysical Observatory, Cambridge, MA; Massachusetts Institute of Technology, Cambridge; and the Space Research Organization Netherlands, Utrecht. The Smithsonian Astrophysical Observatory is the mission operations prime contractor. They maintain the Chandra X-ray Center and Chandra Operations Control Center in Cambridge, MA. The X-ray Center performs science data analysis and data distribution, working with astronomers around the globe to research the high-energy phenomenon of the universe. The Operations Control Center serves as the real-time command and control facility for the Chandra spacecraft and is staffed around-the-clock to provide mission planning and on-orbit operations.

FY 2000 Chandra X-Ray Observatory Metrics and Performance

Fully acceptable performance is defined as instruments meeting nominal performance expectations, completing 80 percent of preplanned and commanded observations with 95 percent of science data recovered on the ground. Minimum acceptable performance is defined as the loss of one or both gratings, and/or loss of an entire focal plane instrument, and/or loss of the second focal plane instrument, as long as imaging capability is available. Complete 40 percent of preplanned observations with 75 percent of science data recovered on the ground.

Chandra exceeded all performance metrics, including exceeding 99 percent of preplanned commanded observations and roughly 99.9 percent of science data recovered on the ground.

Scientific Payloads and Research

Cosmic Ray Astrophysics

Scientists at Marshall are studying high-energy calorimeter techniques for a future space station mission to measure the highest energy nuclei in nature. The Advanced Cosmic-ray Composition Experiment for Space Station (ACCESS) will study the energy spectra and composition of galactic cosmic rays to reveal their source and the acceleration process that produces them. Together with colleagues from several universities, Marshall scientists have tested several detector concepts in a high-energy particle accelerator at the European Center for Nuclear Research (CERN). These tests will define the instrument to be proposed for the Space Station experiment scheduled for launch in 2007.

Gamma-Ray Astronomy

For the first time, a significant number of soft gamma ray repeater bursts (SGRs) from observations with Burst and Transient Source Experiments (BATSE) on Compton Gamma Ray Observatory, the Rossi X-Ray Timing Explorer and the Italian satellite BeppoSAX have been used to deduce the statistical properties of these objects. The results support the neutron star crustquake model for SGRs. Two gamma ray transients were detected with BATSE and were identified at x-ray and radio wavelengths. One of these transient sources, in outburst again after more than a year in quiescence, showed the signature of a radio ejection event, consistent with the hard-soft transition model for this class of sources.

X-Ray Astronomy

Within the x-ray astronomy group, the engineering balloon flight of the high-energy-replicated-optics payload marked an important advance in our endeavor to provide low-cost, focusing x-ray optics for hard x-ray astronomy. Development successes this year included fabrication of the iridium-coated mirrors and the x-ray detector, and a unique day-night star camera for pointing these narrow field-of-view optics. Further balloon flights are planned as we begin the first efforts to study the hard x-ray sky with focusing optics.

Space Plasma Physics

With the launch of the IMAGE satellite, researchers can, for the first time, obtain images of the magnetosphere in energetic neutral atoms, extreme ultraviolet and far ultraviolet wavelengths. The images are showing that the inner magnetosphere is a dynamic environment with unexpected features that scientists at MSFC are now analyzing. Global far-ultraviolet images of the aurora from the Polar satellite have revealed a correlation between the amount of energy deposited in the dayside ionosphere and the magnitude of the pressure enhancement in the solar wind. Aurora activity is observed only when the force exerted on Earth's magnetosphere by the solar wind exceeds a certain threshold.

Solar Physics

Solar activity prediction techniques were improved upon by MSFC solar scientists. Long-range predictions for the level of solar activity months to years in advance now provide reliable estimates. Short term predictions for the likelihood of a solar flare, hours to days ahead of time, are facilitated by observations of the strength and direction of the magnetic field in the vicinity of a sunspot and by observations of S-shaped coronal structures in x-ray images of the sun. These improvements in solar activity prediction techniques provide a better understanding of the sun and its effects on life and society.

Astrobiology

Astrobiologists at Marshall collected microbial extremophiles from glaciers, permafrost and cryoconite of North Siberia, Alaska, and the central Antarctic ice sheet. Strains of unusual microorganisms were isolated and grown in pure culture, including psychrophilic and psychrotrophic bacteria, archaea, cyanobacteria, fungi, and diatoms. These isolates are now being studied to determine if the microbial ecosystems of permafrost, glaciers, and cryoconite rock/ice/water interfaces could provide models of possible life forms that might inhabit glaciers, permafrost and polar ice caps of Mars, Europa, Ganymede, or other frozen worlds of the Cosmos.

Gravity Probe-B

MSFC manages the Gravity Probe B science payload development and will manage the upcoming science mission. This mission will measure key features of Einstein's General Relativity theory by making precise measurements of the space-time continuum in near-Earth orbit. The significant highlight for the program in FY 2000 was the completion of the science instrument refurbishment, including a thermal repair and gyroscope replacement, and the subsequent fully successful retest.

The Gravity Probe-B flight payload assembly, consisting of the 2400-liter dewar of liquid helium and the flight probe, is shown being prepared for integrated payload testing.

FY 2000 Gravity Probe-B Metrics and Performance

Complete final integration and test of the GP-B science payload.

The launch date was moved to October 2002, to allow time for the repair of flight hardware anomalies encountered during verification testing. The first phase of retest following the repairs was fully successful.

Mission lifetime of 16 months.

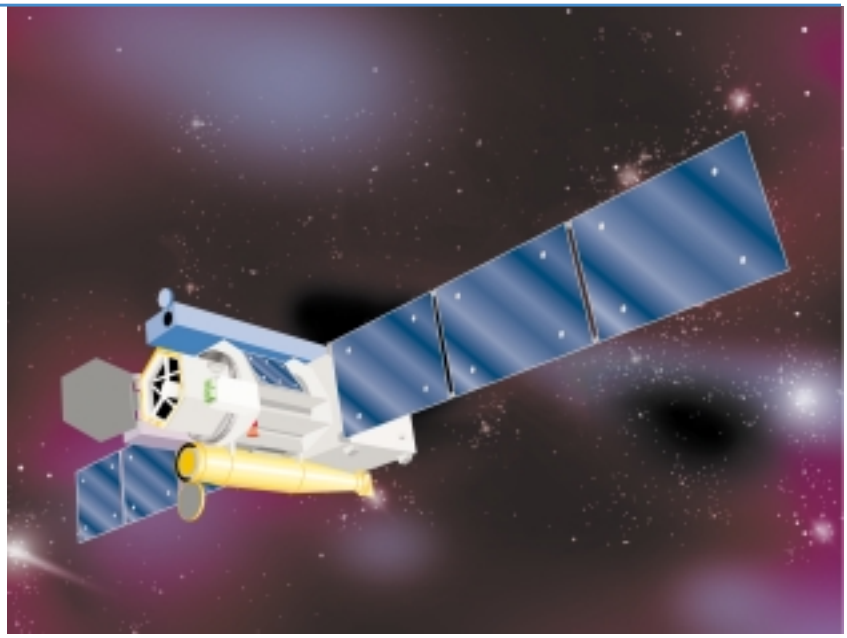
Metric is on track.

Measurement accuracy for relativistic drift of 0.5 milliarcseconds per year.

Exceeding this by a factor of 2.

Solar-B

MSFC also manages the U.S. contribution to the Japanese Solar-B mission. The goal of this international mission is to increase our understanding of the Sun and its impact on Earth. Scheduled for launch in 2005, this mission includes a significant contribution from the U.S. investigators and industry. In 2000, the Preliminary design reviews were completed. Delivery of the engineering models of the U.S. supplied payload elements is planned for 2001.



FY 2000 Solar-B Metrics and Performance

Launch Readiness by August 2004

Launch was moved to September 2005 per the request of the Institute for Space and Astronautical Science (ISAS)/Japan. Requirements review was completed in September 1999. Concepts studies were completed in October 1999. preliminary design reviews were completed in May 2000.

Mission Lifetime of 3 years

Metric is on track

Engineering Models by February 2001

Delivery of the engineering models was moved to July 2001 to reflect new launch date and to accommodate Japan schedule

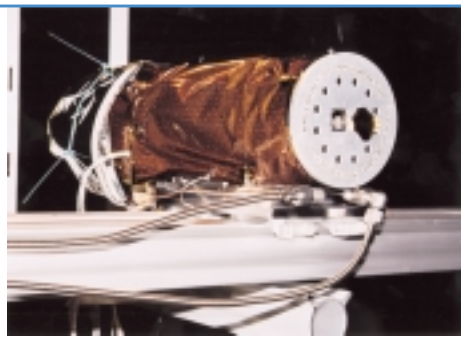
Focal Plane Instrument to ISAS by October 2002

Delivery of the focal plane instrument to ISAS was moved to September 2003 to reflect new launch date

0.5-Meter Optical Telescope resolution of 0.25 arcseconds

Focal plane instruments on track to preserve the highest resolution of which the telescope is capable (<0.25 arcseconds).

Solar X-Ray Imager



Another MSFC payload is the Solar X-Ray Imager scheduled to fly on the NOAA Geostationary Operational Environmental Satellite (GOES)-M satellite. The instrument serves as a solar activity monitor by imaging the x-ray emission from the Sun. The Solar X-Ray Imager is presently integrated on the GOES-M spacecraft and is scheduled to launch on July 12, 2001.

FY 2000 Solar X-Ray Imager Metrics and Performance

Launch on GOES-M October 2000

Launch was delayed to "no earlier than July 2001" due to NOAA operational launch schedule and is currently scheduled for July 2001. The Solar X-Ray Imager is integrated to the GOES-M spacecraft and systems level environmental tests are completed.

GOES-M combination mission red team review/ external independent readiness review was held on February 20-22, 2001 and the Pre-ship Review was held on March 6, 2001. The GOES-M satellite is being shipped from Space Systems/Loral to the Launch Base on April 9, 2001.

Mission lifetime of 3 years

Metric on track and valid.

Full-disk soft x-ray imaging of the Sun, including solar flares and coronal holes.

Instrument performance was verified at integrated systems level.

National Space Science and Technology Center

The National Space Science and Technology Center (NSSTC), headquartered in Huntsville, Alabama, is a research and education institution that provides an environment for selected key scientific disciplines. It consists of researchers and resources from government, academia and industry collaborating in an environment that enables cutting edge basic and applied research and fosters education of the next generation of scientists and engineers. It is a unique blending of people, facilities and tools to encourage advances in Earth science, space science, biotechnology, optics and energy technology, propulsion physics, materials science and information technology.

The research performed by the NSSTC covers the range of maturity from pure science to technology development to mission operations and data analysis. In appropriate disciplines, laboratory experiments, sounding rockets, balloons and aircraft are used as platforms for the investigations being pursued. Where appropriate, experiments are flown on manned and unmanned spacecraft. Educational activities include both graduate level and undergraduate level for students at the partnering educational institutions. Partnering educational institutions currently include the University of Alabama, University of Alabama Huntsville (UAH), University of Alabama Birmingham (UAB), Auburn University, Alabama A&M University, and the University of South Alabama.

The NSSTC is a partnership between NASA and the State of Alabama through the Alabama Space Science & Technology Alliance (SSTA) to perform research meeting the nation's needs. The NSSTC is the culmination of the efforts of NASA and the State of Alabama over a two-year period in which NASA invested $9 million and Alabama invested $6.9 million to acquire the core facility for the NSSTC. The University of Alabama in Huntsville, acting as the fiscal agent for the state, procured a facility and executed the renovations. Occupancy of the facility occurred in August 2000 with the move of the Global Hydrology and Climate Center.

During FY 2000, Center Operations established the information technology infrastructure at the NSSTC. Network services to support a state-of-the-art Internet Protocol (IP) telephony system were fully put in place, now serving nearly 400 NASA civil servants, NASA contractors, and UAH personnel. Processes for continuing configuration management, access control, and problem resolution were also established for the collaborative work environment at NSSTC.

Global Hydrology Climate Center

Research in Earth Science at MSFC is performed by the Earth Science Department in a partnership with the University of Alabama in Huntsville and others at the Global Hydrology and Climate Center. This unique research and academic community is part of the National Space Science and Technology Center.

A major effort at the GHCC in 2000 was the application of remote sensing data to the development of a better understanding of the urban heat island effect. The assessment of land use changes in Atlanta using Advanced Very High Resolution Radiometer (AVHRR) and Landsat TM satellite data and high-resolution (10 m) thermal IR aircraft data continued, in partnership with state, local, and regional government entities within the Atlanta area, as well as with private industry and non-profit organizations. Models on urban heat island-forced cloud development over the Atlanta area from Geostationary Operational Environmental Satelite (GOES) and AVHRR data were developed and demonstrated a significant effect, providing and better understanding of the results of continued analysis of urban heat island-forced precipitation events over Atlanta as observed using standard meteorological data. The figure above shows the effect of the urban heat island on the development of regional thunderstorms. After the initial formation of convection formed within the Atlanta area and moved eastward, a regional complex of thunderstorms developed. This research has been documented in an article in *Atmospheric Environment.* Detailed, physical modeling has shown how cooling the surface of the Atlanta metro area via tree planting and installation of highly reflective roofing materials can potentially drive down ozone production over Atlanta progressed significantly. Many of these techniques were applied to other cities, namely Baton Rouge, Salt Lake City, Sacramento, and Houston, in partnership with the EPA and with local governments. This research has generated a large amount of interest from the media. The MSFC scientists and their partners were interviewed for reports by CNN, CBS News, ABC News, The Weather Channel, and the BBC. Stories on the urban heat island work also appeared in a host of newspapers and magazines including *The New York Times, The San Francisco Chronicle, the Sydney (Australia) Morning Herald, and The Times of London.*

Research on remote measurement of lightning activity and the processes involved in the severe storms that produce lightning remained a major focus of the Earth Science Department. After three years as part of the Tropical Rain Measuring Mission (TRMM) the Lightning Imaging Sensor (LIS) is still healthy and will continue to monitor tropical lightning through the TRMM mission. The figure 3 on page 45 shows a compilation of that data for the three-year period. Satellite data were also used to demonstrate a 200% increase in Gulf of Mexico thunderstorm days during the 1997-98 El Niño event, and to demonstrate that plumes of nitrogen compounds observed over the North Atlantic Flight Corridor were in part generated by thunderstorm lightning. Results from scientific analysis of data from LIS and a previous instrument on a higher inclination orbit has shown quantitative promise for the use of lightning observations from space in the forecasting of severe weather. An interesting result that we have found is a strong geographical variation in the ratio of in-cloud lightning to that hitting the ground (figure 3). High values of this ratio are coincident with regions of peak severe storm occurrence. This information, especially if it can be obtained from a geostationary sensor, can have important applications in preserving human safety, as well as in management of local and regional disaster services. Through the Global Hydrology Resource Center, the LIS Team has distributed many gigabits of satellite and surface lightning data to users in a number of countries. This support further included a ground-up revision of the LIS data processing code to improve data quality and consistency, leading to a reprocessing of the data that is currently ongoing.

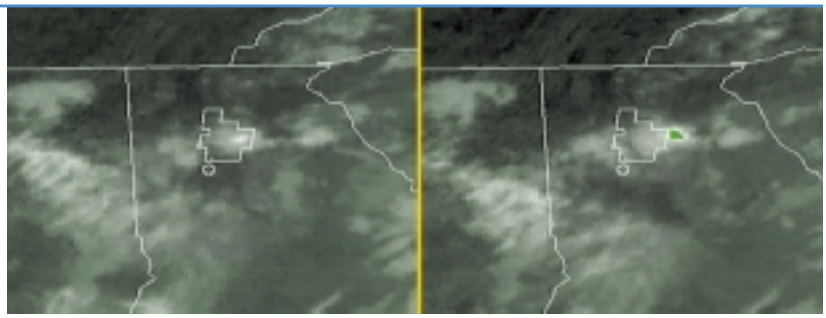


fig. 3

A significant portion of the Earth Science research addresses interannual variations such as El Niño / La Nina. This global phenomenon occurs when there is a large-scale anomaly in water temperature in the eastern Pacific Ocean – warm in the case of El Niño, and cold for La Nina. Studies conducted by the infrared remote sensing group used 19 months of GOES data over the Americas to evaluate the variability of upper-tropospheric water vapor and its transport during the 1987/1988 El Niño Southern Oscillation (ENSO) period. Significant seasonal and interannual variability exists, especially over Brazil as monsoonal precipitation regions change with the transition from the 1986-1987 El Niño to the La Nina of 1988. This has a dramatic affect on upper-level hemispheric transport over the Americas. Current research focuses on the 1997-1999 ENSO period and will be contrasted with the previous work. Utilizing space-based remote sensing to perform research into the hydrologic cycle and its role in interannual variability of tropical climate has yielded many interesting findings, such as significant increases in precipitation over the ocean during El Niño episodes. Accompanying these precipitation events we have found evidence of increased trapping of infrared radiation that exits the top of the earth's atmosphere. This is consistent with a positive water vapor feedback in that increased sea surface temperatures allow for accumulation of more water vapor that retards the efficiency with which the tropical climate can reject radiative energy to space. This work makes use of a NASA/NOAA pathfinder data set that was produced at Goddard Space Flight Center (GSFC). MSFC scientists have worked with their GSFC counterparts to study this mechanism.

Water vapor is the most important greenhouse gas yet the measurement of it in the upper troposphere continues to be a difficult challenge. Small changes in the upper-troposphere can significantly affect outgoing longwave radiation. The comparisons of upper-level water vapor products derived from by satellites (microwave and infrared) agree only to a first order. New research has conducted an intercomparison of results of radiative transfer codes that are used to simulate the upper-level water vapor measurements. There is much variability in the radiative transfer models, which could explain the differences in the derived water vapor fields.

NASA and the Central American Commission on Environment and Development (CCAD) recently teamed up to cooperate in the development of the Mesoamerican Biological Corridor (MBC). Home to rare and endangered species as well as human inhabitants, the goal of the MBC is to integrate conservation, protection, and ecological balance within the framework of sustainable economic development. To provide key assistance in this effort, a Japanese Earth Resources Satellite (JERS) mosaic of the region has been completed. This data will be incorporated into the MSFC database and transferred to the Central American researchers to assist in determining protected areas for the continued migration of bird and animal species. A prototype web page for this project may be found at http://ghrc.msfc.nasa.gov/ccad

FY 2000 Global Hydrology Climate Center Metrics and Performance

Provide two demonstrations of improvements to climate modeling based upon utilization of operational satellite data in FY 2000.

An initial study was completed that quantified interannual variability of precipitating ice particles in deep convection over the tropical oceans and showed how it strongly related to sea-surface temperature. This finding helped point out remaining uncertainties in Tropical Rainfall Measuring Mission (TRMM) algorithms. We discovered and provided a correction for an error in the estimate of surface long wave radiation when analyzing the Langley 8-Year Surface Radiation Budget data set (SRB). This analysis subsequently allowed reconciliation of differences between the SRB and an array of current climate model simulations, thus providing a first order verification of their predictions.

Establish a partnership with the NOAA forecast office for use of advanced satellite data to improve operational forecast models on a regional scale in FY 2000.

Earth Science Department personnel have submitted a joint paper demonstrating improved precipitation forecasting with the National Weather Service to the 2001 Weather Analysis and Forecasting conference on the Summer Convective Rainfall in Alabama Prediction Experiment. The Birmingham forecast office is now using our data sets in making their routine forecasts.

Publish three scientific papers on the relationship between lightning and severe storms; establish an agreement with NOAA for flight of a lightning imaging sensor in geosynchronous orbit in FY 2000.

Over ten journal articles were produced by the MSFC atmospheric electricity team, covering various subjects including the importance of in-cloud versus cloud-to-ground lightning for storm diagnostics and prediction, and the effects of El Niño on thunderstorms in the southeastern U.S. as evidenced in space-based and other lightning data.

Complete mosaic of Central America from the Japanese Earth Resources Satellite (JERS–1), provide initial training of Central American participants, and complete two site intensive field campaigns within the region in FY 2000.

The JERS (Japanese Earth Resources Satellite) mosaic has been completed, which enables Central American researchers to better analyze and understand the Mesoamerican Biological Corridor. Two intensive in-country training workshops were conducted, including remote sensing analysis and field campaigns. Further, more detailed, field campaigns are planned in the near future.

Complete regional assessment of Southeast U.S. and integrate into national assessment process in FY 2000.

The Southeast regional assessment has been completed, and the national assessment is ongoing, with our participation.

Restructure wind remote sensing program in collaboration with GSFC and complete ground validation of key coherent lidar sub-systems in FY 2000.

Discussions are still ongoing with GSFC and Langley Research Center regarding the centers' roles and responsibilities. Completing the SPARCLE hardware is not yet finished, with a new target date of April, 2001. Ground validation of subsystems as part of an integrated lidar system has been cancelled due to key personnel leaving.

Complete baseline thermal characteristics of five major U.S. cities in collaboration with state and local government in FY 2000.

Baseline thermal characterization of five major US cities is progressing. Calibration of visible, reflective IR, and thermal IR channels of airborne multispectral remote sensing data for use as a source for determining thermal temperatures and albedos of various urban surfaces will be completed within two months.

Process, validate, archive, and provide accessibility to continuing data sets from OTD, LIS, and AMSU in FY 2000.

Achieved goal of acquiring, processing, archive, validating and distributing data for OTD, LIS, and AMSU on an automated operational basis 7 days a week. Data accessibility to the public through an online web ordering system and through a manned 8x5 User Services Office was achieved. The OTD acquisition contract ended in FY 2000, so data is no longer being acquired. LIS and AMSU operations continue.

Principal Center Support Activities

NASA Automated Data Processing Consolidation Center (NACC)

The NASA Automated Data Processing Consolidation Center (NACC) provided highly available (99.9 percent) and cost-effective mainframe computing systems for 15 different Agency workloads during FY 2000. Additionally, the FY 2000 Program Operating Plan (POP) cost projections for FY 2001 were 11.6 percent lower than the costs forecast for FY 2001 in POP 1999. Cost decreases for FY 2001 are directly attributable to continued standardization of hardware and software systems and support and replacement of old technology.

During FY 2000, the NACC upgraded the operating environments for 12 of the 15 Center workloads it supports. Additionally, all disk storage was upgraded to new technology Redundant Array of Individual Disks (RAID) storage, increasing performance and capacity while decreasing maintenance costs, floor space, and cooling. Also, obsolete tape drives and tape storage systems were replaced with new virtual tape technology, improving performance while decreasing drastically the size of the Agency's magnetic tape libraries. Agencywide licensing was established with Xerox Corporation.

Communications Architecture and Providing Agencywide Area Network Services

An Agencywide communications architecture technical framework has been completed and accepted as a NASA standard. This framework will be utilized to support the new eNASA initiative as well as to provide an information technology roadmap for the Integrated Financial Management Program.

Digital Television (DTV)

The MSFC DTV Project Lead served as the lone technical representative on the selection committee that reviewed and negotiated a landmark commercial deal between NASA and DREAMTiME Holdings, Inc. The Space Act Agreement with DREAMTiME is considered the most significant commercial International Space Station agreement thus far, and is serving as a pathfinder for the Agency. The MSFC DTV Project Lead is serving as the Deputy Collaboration Manager for implementation of the overall agreement with DREAMTiME, with emphasis on deployment of DTV at all field centers, as well as space DTV projects. MSFC was responsible for planning and leading a crew to document Expedition One related activities in Russia. To facilitate deployment of HDTV across the Agency, a HDTV standard was set by the Principal Center for Communications Architecture, having accepted the recommendation of the MSFC led NASA DTV Working Group.

Sustaining Engineering Support for Agencywide Administrative Systems (SESAAS)

SESAAS continued to provide sustaining engineering support to the Agencywide administrative systems. All of the SESAAS applications safely transitioned into the Year 2000. Regulatory/statutory and policy changes were implemented expeditiously into the various applications, including the NASA Personnel/Payroll System, Consolidated Agency Personnel/Payroll System, Acquisition Management System, NASA Equipment Management System, NASA Property Disposal Management System, and NASA Supply Management System.

Earned-Value Management (EVM) Plan

During FY 2000, the MSFC Earned Value Management (EVM) team provided assistance, guidance and consultation to MSFC Project Offices and other NASA centers concerning the implementation of earned value on NASA contracts. The EVM team also participated with other government agencies (OMB, DOD, FAA, etc.) and industry partners

in various forums to foster consistent EVM policy and implementation approaches throughout the federal government. Coordination activities among the NASA EVM Focal Point Council, the Boeing Company, and the Defense Contract Management Agency (DCMA) resulted in a signed EVM Advanced Agreement (AA) with the Boeing Company. This document acknowledged that the Boeing Company's single EVM system was in conformance with ANSI/EIA Standard and documented Boeing's intent to maintain their EVM system compliance through joint surveillance. Additionally, a Memorandum of Agreement (MOA) was developed and coordinated between NASA and the DCMA for consistent surveillance support for NASA contracts. This document will benefit NASA project offices by clarifying DCMA responsibilities for surveillance and program reporting activities.

NASA Preferred Technical Standards Program

In FY 2000, the NASA Technical Standards Program Office supported the Center's Program/Projects and Engineering Directorate needs by providing online technical standards products. In providing these and additional capabilites, this program office saved the Center 75 percent (about $300K) of previous costs for these services. The Program Office also developed and obtained approval from the NASA Chief Engineer for a new NASA Integrated Technical Standards Initiative.
This unique initiative consists of three key elements: an Agency-Wide Full-Text Technical Standards System, a Standards Update Notification System, and a Lessons Learned/Best Practices/Applications Integration System. This initiative will be implemented Agency-wide during FY 2001. MSFC's Programs/Projects and Engineering Directorate have especially benefited by serving as the "Pilot" for implementation of the Initiative. For FY 2000 the NASA technical standards program goal to increase NASA participation in non-Government standards developing organizations by 10% over FY1999 was achieved. The Program Office achieved a 125 percent increase in technical standards products developed, adopted or identified for adoption as NASA Preferred Technical Standards exceeding the goal of a 100 percent increase.

Space Environments and Effects (SEE) Program

Major accomplishments for the SEE Program in FY00 included the development of the Interactive Spacecraft Charging Handbook. The handbook is a preliminary design tool used to predict the simple effects of spacecraft charging on satellites. Tools include Geosynchronous and Trapped Radiation Charging Environments, and Surface Deep Dielectric and Auroral Charging. The contract was completed in FY 2000 and the handbook is available to the spacecraft environment community through NASA's Space Environments and Effects Program.

NASCAP-2K, which is a collaborative effort between the SEE Program and the US Air Force to provide a detailed and comprehensive revision to the NASCAP spacecraft charging analysis codes, was also developed. The second year of a five-year development schedule began in FY00. Progress thus far shows the task on-schedule and within budget. A complement to the Interactive Spacecraft Charging Handbook, the scope of NASCAP-2K is much larger and much more detailed than the Handbook and will provide grid resolutions and detailed analyses not available anywhere else in the world.

The year also saw the development of the Satellite Contamination and Materials Outgassing Knowledgebase, which is an on-line knowledgebase of material outgassing information from ASTM 1559 and quartz-crystal microbalance (QCM) flight data. Data was obtained from national and international organizations and space agencies. Much more than just a database, the Knowledgebase enables the user to download and plot data, has PDF format reference materials and has search capability. The contract was completed in FY00 and final product is available to the spacecraft environment community through NASA's SEE Program.

Integrated Financial Management (IFM) Program

The goal of NASA's Integrated Financial Management Program is to improve financial management throughout the Agency. In April of 2000, the Agency completed a restructuring of the program and a new program office was established at NASA HQ. A formal Program Commitment Agreement (PCA) was signed for the new program on September 25, 2000.

The mission of the IFM Program is to improve the financial, physical, and human resources management pro-

cesses throughout the Agency. IFM will reengineer NASA's business infrastructure in the context of industry "best practices" and implement enabling technology to provide necessary management information to support the Agency's strategic plan implementation.

Successful implementation of the program will allow NASA to:

- Provide timely, consistent, and reliable information for management decisions
- Improve accountability and enable full cost management
- Achieve efficiencies and operate effectively
- Exchange information with customers and stakeholders
- Attract and retain a world class workforce

MSFC is playing two major roles in the IFM Program. They include the following:

IFM Core Financial Project

The Center was chosen to manage the Core Financial Project, which is the first of several potential IFM projects. The IFM Core Financial Management Project provides the management and technical leadership for the Agencywide implementation of standard systems and processes necessary to support the Agency's financial management activities. The Core Financial Project will provide the backbone of the IFM program and consists of the following components: standard general ledger, accounts receivable, accounts payable, budget execution, purchasing, fixed assets, project accounting, and cost allocation. In addition to managing the project, MSFC will serve as the pilot center for implementation of the core financial software. NASA has selected new vendors for the core financial module. SAP Public Sector and Education, Inc. will provide the software and Accenture (formerly known as Andersen Consulting) will provide implementation services.

IFM Integration Project

MSFC was also selected to manage the long term IFM Integration Project. The Project manages all functional, application, and technical integration within the scope of the IFM program. The IFM Integration Project is responsible for ensuring that the individual IFM software modules work together and collectively satisfy the defined Agency IFM business drivers. The Integration Project will also be responsible for maintaining the Agency business and software applications architecture, and designing and implementing the information technology architecture that supports the deployment and operation of the IFM modules.

NASA Operational Environment Team (NOET) Plan

The NASA Operational Environment Team (NOET) established many goals during FY 2000 that became significant accomplishments. One such accomplishment was the successful planning, development, and execution of the 4th Conference on Aerospace Materials Processes and Environmental Technology (AMPET) held at the Von Braun Center in Huntsville, Alabama from September 18–20, 2000. AMPET provided the forum for 515 engineers, scientists, and managers to gain knowledge from the 106 technical papers that were presented on evolving materials, manufacturing, and environmental technologies essential for maintaining a competitive edge for upgrading existing systems and developing future airframe, propulsion, transportation, and structural hardware systems. The following organizations were AMPET co-sponsors: NASA's Materials and Processes Working Group, Office of Space Flight at NASA Headquarters, National Center for Advanced Manufacturing, American Institute of Aeronautics and Astronautics, ASM International®, Aerospace Industries Association, Environmental Protection Agency, Nation Center for Manufacturing Sciences, SAMPE, Sandia National Laboratories, and University of New Orleans.

A second milestone was the establishment of a Memorandum of Agreement (MOA) between NASA Headquarters and MSFC to appoint MSFC as NASA's Principal Center for the review of the Clean Air Act (CAA) regulations. The MOA set forth the responsibilities of NOET to support and assist Headquarters, Code JE, in the management of NASA's review of EPA-proposed CAA regulations that may impact NASA program hardware and supporting facilities.

Another accomplishment was a revision to the NOET Charter. A memorandum from Code J, dated April 14, 2000, required a revision of the NOET Charter in order for MSFC to maintain its Principal Center function as champion of the operational environment. This revision was made and approved by Mr. Arthur Stephenson on December 5, 2000. During this charter revision process, NOET was changed to the NASA Materials Replacement Technol-

ogy Team (NMRT2). This name change occurred to underscore a new emphasis on materials, processing, and manufacturing technology.

NOET / NMRT2 also developed partnering relationships with other operational entities such as the Shuttle Environmental Assurance (SEA) Initiative and the Joint Group on Pollution Prevention (JG-PP). The SEA Initiative focuses on ensuring continued environmental compliance of Space Shuttle Program elements through awareness, communication, and resolution of environmental, materials obsolescence and materials replacement technology issues. JG-PP is a partnership between the DoD, NASA, and industry, with the goal of reducing the duplication of effort when testing alternatives to hazardous materials.

NASA Acquisition Internet Service (NAIS)

The NASA Acquisition Internet Service (NAIS), an Agency-wide service under the leadership and technical expertise of MSFC, achieved several successes in 2000. The Virtual Procurement Office (VPO) continued to evolve as the standard user interface to all procurement tools (rules, samples, and document generation / processing applications). VPO's initial success has attracted interest among several other federal agencies.

The NAIS group introduced the Past Performance Database System (PPDB), a web-based application enabling procurement representatives throughout the Agency to share contractor performance evaluations. The on-line past performance evaluation data maintained in PPDB are utilized in the evaluation of competitive proposals on new acquisitions.

The Agency Chief Information Officer (CIO) selected and funded a NAIS proposal to pilot strong authentication utilizing the Agency's Public Key Infrastructure (PKI). The pilot will pursue concepts to establish a single-point logon, which will control access authorities for all NAIS applications.

The most noteworthy achievement was the successful migration of all NAIS applications from a costly proprietary database environment to an open-source environment. The migration to the open-source database environment has enhanced performance of the NAIS applications and reduced the annual database charge by over $100,000.

NASA Integrated Services Network (NISN)

In FY 2000, NISN provided wide area video, voice, and data services to Agency customers at or above the established standards of excellence. NISN systems successfully rolled over to the Year 2000 with no impact. In addition to managing services such as video teleconferencing, administrative and mission voice, facsimile, intercenter mission and administrative data, and Internet access, significant effort was expended to meet new requirements for the Earth Observing System and International Space Station programs. NISN mission systems and operations staff supported shuttle launches STS–99, STS–101, STS–103, STS–106, and launches of the Sealaunch, Taurus, Delta, Atlas, Proton, Titan, and Pegasus vehicles. In FY 2000, NISN transitioned the Agency's long distance voice service from AT&T to Worldcom (MCI) as part of a Governmentwide project to migrate services from the expiring contract with AT&T to the replacement contract with Worldcom; transition of videoteleconferencing services to the new contract was also initiated. NISN Uninterruptible Power Supply (UPS) systems were replaced at six NASA centers; videoteleconferencing rooms were upgraded across the Agency; the dedicated DS3 backbone was transitioned to Asynchronous Transfer Mode (ATM); and an initiative to migrate NISN mission services to ATM was initiated. Real-time performance metrics reports are now available electronically from the NISN home page. NISN provided user training on the voice teleconferencing services and initiated an electronic customer satisfaction survey form. An annual customer forum was held to brief customers on service offerings and initiatives and to solicit customer input to improve NISN services and supporting processes.

Defense Contract Administrative Service Financial Management Support

MSFC is responsible for NASA's Financial Management Support for Agency Contract Administration and Audit Service (CAAS). In FY00 this included responsibility for maintaining the system for cost and billing information and Agency level accounting data for CAAS services provided to NASA from external organizations. MSFC also had responsibility for NASA Financial Management Support for Agency Reimbursable Collections of Contract Administration and Overhead from NASA reimbursable customers.

National Center for Advanced Manufacturing (NCAM)

The agency established the National Center for Advanced Manufacturing (NCAM), giving Marshall the principal center designation for managing the initiative. The NCAM has been created to address the research and technology development needs to assure world class capabilities exist for manufacturing current and future space transportation systems. NCAM will build a stronger manufacturing engineering research and development organization that provides leadership for NASA and industry, and is ultimately enabling to the development of space transportation systems with orders of magnitude improvement in safety, cost, and reliability. The concept of NCAM is defined by partnerships with other NASA centers, government agencies, academia, and industry. The inclusion of industry and education in this effort will improve the ability with which we generate and transfer technologies and innovation, it will also inspire increased educational opportunities, ensure a trained workforce and help to strengthen the US position in the competitive marketplace. During FY 2000 significant progress was made toward achieving the mission of the NCAM for manufacturing space transportation systems through collaboration and partnerships.

Partnerships at MSFC's Michoud Assembly Facility (MAF) with the State of Louisiana, the University of New Orleans, and the Lockheed Martin Corporation were formalized through a memorandum of understanding. A major accomplishment at the MAF included the procurement of a highly advanced fiber placement machine to be used for research and development and for production and training. Other accomplishments included preparation of the government facility for installation of the machine, and completion of classrooms/videoconferencing center for teaching graduate level courses in advanced manufacturing. A partnership with Calhoun Community College was formed to develop an intelligent manufacturing system that will allow virtual and collaborative engineering and training between Calhoun's new Advanced Manufacturing Training Facility and Marshall's NCAM facilities. Students trained in this facility will provide a technologically current workforce for the Boeing Delta IV plant in nearby Decatur, AL.

Successful outreach to NASA projects, other government agencies and academic institutions in FY 2000 will provide the opportunity for many new partners in coming years, truly transitioning NCAM from regional to national prominence.

NASA Engineering Excellence Initiative/ Agency Systems Engineering Working Group (SEWG)

The Agency SEWG is being led by the Deputy Chief Engineer for Systems Engineering out of HQ/Code AE. The expectations of this working group are to help address Agency needs specific to consistency in the basic approach to systems engineering, a common framework of recognized best practices that guides the systems engineering of aerospace program and project products and capabilities, common systems engineering terminology and definitions to enhance communication and collaboration among engineering teams across the Agency and with external partners and customers, and providing a basis for assessing and continuously improving systems engineering capabilities. Each NASA Center, including JPL, and each HQ Enterprise has provided representatives that will be members to the SEWG. The SEWG kickoff meeting was held on December 5, 2000 with regularly scheduled working sessions to follow throughout the coming year. The SEWG replaces previous efforts known as NASA Engineering Excellence Initiative and NASA Engineering Infrastructure.

Other Support Activities

Spacelink

NASA Spacelink enhancements during FY 2000 include the creation of two new features: On-line Educational Activities and an Alphabetic Index.

The On-line Educational Activities permit students to explore NASA through guided research, leveraging information from existing NASA websites. The activities are ready for use in the classroom or computer lab and require minimal teacher preparation time. The Alphabetic Index was created as a result of benchmarking reviews of other informational websites. The Index, which has proven to be extremely useful, allows quick searches of Spacelink content by title.

Human Resource and Payroll Information Systems

A comprehensive schedule for the replacement of agency administrative systems indicates that major human resource and payroll system capabilities will be addressed no sooner than 2003. This schedule is based on available funding, and complexity of the system modules. Additionally, a preliminary evaluation of the software chosen for the core financial module was performed against the human resource and payroll requirements. Although the software had many strong points, it was found not to meet certain critical requirements at this time. Two pathfinder modules, Resume Tracking and Position Management have been authorized for early implementation. Resume Tracking is scheduled for deployment across the agency starting in the second quarter of 2001.

NASA Secure Network (NSN)

Center Operations provided leadership and technical expertise in helping coordinate and define Agency requirements to develop a dedicated NASA Secure Network. The NSN is a Web based classified network encryption system with MSFC serving as a "managed gateway" for the Agency. The NSN is designed to provide secure Internet access to Intelligence Community Web sites.

Environmental Assessments During FY 2000

The MSFC Environmental Engineering Department conducted risk analysis for 27 flight trajectories located on Western Test Range in support of the X–34 contract. Results of this analysis were presented to Department of Defense, Federal Aviation Administration and other cooperating and reviewing organizations. Additional support was provided for the Range Commanders Council meetings for the purpose of establishing consistent policy regarding public risk criteria associated with flight test projects, and serving as members of the Risk and Lethality Commonality Team.

Agency Logistics Business Systems

Logistics Business Systems Operations and Maintenance Leadership was provided in implementing and sustaining Agency logistics business systems that provide the necessary automated tools to professionals supporting the NASA workforce. These logistics business systems provided responsive and cost-effective logistics business systems to all NASA strategic enterprises and logistic business process customers.

A*STAR

During FY 2000, the development of the web-based STARLearner application of the A*STAR suite which allows individuals to access and manage their personal training was completed. The training community is anticipating the deployment of the web-based version during FY 2001. This program offers individuals access to training information, including personal development plans, training history, current enrollments, as well as an on-line catalog. The new version will provide the capability for individuals to access and complete skill assessments, review skill gap analysis, complete training evaluations, and enroll directly through the training catalog.

Institutional Products and Services

Marshall Technology Transfer

The Marshall Center's Technology Transfer Department utilizes focused program areas designed to innovate, incubate and accelerate technological advances—from conception, through development, demonstration and commercial realization. It is a strategically focused program ensuring that NASA's scientific and technological advances help to sustain the competitiveness of U.S. industry. A few examples follow.

Compressed Symbology Data Matrix Symbols

This is Not Your Parent's Bar Code

Product identification technology pioneered by NASA for tracking space shuttle parts is being used to mark everything from groceries to automobile parts. The application of compressed symbology, a two-dimensional symbol marking system, to parts marking was developed at NASA's Marshall Space Flight Center for use in the Space Shuttle Program, then commercialized by Marshall's Technology Transfer Department.

The "data matrix" symbol can be applied directly to almost any product or material, even items as small as computer chips, and can withstand the harsh environment of space. The symbol is a small, square-shaped mark resembling a checkerboard. The two-dimensional matrix symbol is capable of storing as much as 100 times as much information as a one-dimensional, linear barcode in the same amount of space. Sales for the 12-month period from June 30, 1999 to July 1, 2000 were in excess of $10 million dollars

Video Image Stabilization and Registration

NASA Researchers Provide a Clearer Picture

NASA researchers Dr. David Hathaway and Paul Meyer — using their expertise and equipment for analyzing satellite video —created technology that can dramatically improve TV images including crime scene videos.

By the end of this year, the FBI and other criminal investigators will be able to use the NASA technology at their own stations. The NASA scientists' invention— called Video Image Stabilization and Registration, or VISAR—will be available in a video tracking and enhancement system developed by Intergraph Government Solutions, a subsidiary of Intergraph Corp. of Huntsville. The company has signed a licensing agreement with NASA to use VISAR in its video analyst system, which offers broadcast-quality analysis features on Intel-based hardware. Video imagery for defense applications will also be improved through another licensing agreement between NASA and BARCO Inc. Display Systems, of Duluth, Ga.

SBIR Work Inducted into Hall of Fame

Life-Saving Technology is Honored

A Small Business Innovation Research (SBIR) project funded through Marshall's Technology Transfer Department has been inducted into the Space Foundation Technology Hall of Fame. The work, being performed in two efforts between the Marshall Center and Wisconsin-based Quantum Devices, was one of only three so inducted in the year 2000.

The research focuses on the medical breakthrough benefits of Light-Emitting Diodes (LEDs). The technology originally was used for commercial plant growth investigations on the Space Shuttle and was adapted for the treatment of cancer and for wound-healing.

The first successful implementation of the light-emitting diode research uses tiny, pinhead-sized LEDs to illuminate drugs injected into cancerous tissue within the brain. More recently, doctors are examining how this technology speeds the healing of hard-to-heal wounds, such as diabetic skin ulcers, serious burns and severe oral sores caused by chemotherapy and radiation. Approved by the U.S. Food and Drug Administration, the project is now undergoing laboratory and human trials.

Center Director's Discretionary Fund

Promoting Innovation in the Workforce

The Center Director's Discretionary Fund (CDDF) provides funding opportunities for well-defined research or technology development projects in scientific or technical areas. The projects are required to be innovative and support new ideas or concepts relevant to current or planned NASA programs, and must be aligned with Marshall's roles and missions and clearly contribute to the core competencies of the technical workforce.

The projects largely are performed in-house, involving outside groups or contractors only to the extent necessary. An important CDDF objective is to cultivate Marshall Center talent through "hands-on" experience. During FY 2000, 32 projects were initiated and 27 former projects were continued with a combined expenditure of $2,283,000.

Technology Investment Program

Providing Seed Money to Advance Commercialization Efforts

The Marshall Technology Investment Program (TIP) is funded and managed by the Technology Transfer Department for the advancement of in-house new and emerging technologies that need an infusion of resources to increase their potential for commercialization. This program is designed to work hand-in-hand with the center's patenting and technology commercialization efforts, in order to maximize opportunities for the commercial success of Marshall-developed inventions and innovations.

Projects selected for funding must be limited to in-house work, must have been formally disclosed, must demonstrate a high probability of commercial success, must be aligned with the roles and mission of the center, and must be of one year duration or less. In FY 2000, more than $1.2 million was provided to 33 projects through the Technology Investment Program with $447,000 allocated to projects in the Engineering Directorate, $415,000 in the Space Transportation Directorate, $114,000 in the Science Directorate, and $281,000 in other center organizations.

New Technology Reporting

Capturing and Sharing Leading-Edge Technologies

One of NASA's primary goals is to share leading-edge technology with the U.S. industrial community. The new technology reporting process provides an avenue for inventors to disclose their inventions, discoveries, and innovations. In FY 2000, 124 new technologies were reported and assessed for commercial potential, with more than $30,000 in incentive awards distributed to civil service and contractor inventors.

Technology Development and Deployment Partnerships

Ingenuity at Work

The Marshall Center's Technology Transfer Department is discovering novel solutions for filling the technology needs of NASA, while supplying NASA ingenuity in ways that help America grow, through partnership opportunities with industry, small business, academia, and other government entities.

The department also works to create partnerships through which educational and commercial partners may use Marshall facilities for a fee. There were 84 agreements active in FY 2000. Reimbursements from these agreements total almost $6.5 million. Of the 84 agreements, 27 related to work in the Engineering Directorate, 21 were in the Science Directorate, 10 were in the Space Transportation Directorate and 26 were in other organizations across the center.

Small Business Programs

Leveraging America's Entrepreneurial Resources

The goal of NASA small business programs, the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, is to strengthen the role of small businesses in meeting federal technology needs.

In FY 2000, 84 active SBIR Phase I and II contracts were in force with a total value of almost $12.5 million. There were also five active STTR Phase I and II contracts valued at almost $1million. In addition, 37 SBIR/STTR Phase III contracts (13 new contracts) were active in FY 2000 with a value of more than $18 million. Phase I awards are presented to determine the scientific and technical merit and feasibility of an innovation; Phase II awards are for the continuation of development of those innovations shown to be feasible in Phase I; and, finally, Phase III covers those activities capitalized by non-SBIR sources of funding for the pursuit of private sector or government sales.

Nationally Syndicated Television Series Spotlights Technology Transfer

Huntsville's AZ Technology Showcased

NASA, Marshall, and the Huntsville community were presented with a unique outreach opportunity in September when *Small Business School*, a nationally syndicated public television series, highlighted the role of the U.S. government in the development of small businesses. Huntsville-based SBIR company AZ Technology was showcased as a success story example. Featured speakers included former NASA astronaut Dr. Larry DeLucas and Dr. Bob Norwood, Director of NASA's Commercial Technology Division.

Technology and Software Commercialization

The Catalyst Uniting Technologies With Commercial Applications

The Marshall Center's Technology Transfer Department works to facilitate the patenting and licensing of Marshall-owned technologies and innovations ensuring that their maximum commercial potential is realized. During FY 2000, Marshall filed 19 patents and six provisional patents resulting in the issuance of eight patents. Six licenses were negotiated and executed, providing more than $72,000 in royalties to the center.

Other Institutional Highlights

Year 2000

MSFC successfully transitioned into the Year 2000 (Y2K). MSFC is the lead Center for IBM mainframe computing and Principle Center for Communications Architecture. MSFC is also responsible for the Agency Wide Area Network. MSFC instituted a Y2K Control Center that was operational around the clock during the Y2K rollover, with many people working to monitor systems to ensure that there were no Y2K anomalies. The Y2K rollover and the Leap Year rollovers occurred without mishap.

Special Events

MSFC sponsored a host of special events during FY 2000. The MSFC Open House was a huge success. MSFC opened its doors for anyone interested in learning about space and MSFC's role in the space program. Attendees came from across the U.S. and other countries. MSFC also hosted a Turning Goals Into Reality (TGIR) Conference where NASA and industry partners gathered to focus on accomplishments of the Agency's goals and objectives. This event was attended by employees from the Agency; the Department of Defense, the Federal Aviation Administration and other government agencies, and included widespread industry participation. FY 2000 also brought MSFC's 40th Anniversary which was marked with a Centerwide celebration. Annual events supported during FY 2000 included the Moonbuggy competition, Retiree Dinner, Safety Day, and the Health and Fitness Expo.

Home Security Awareness

In an effort to extend employee safety and security from the workplace to the home, Marshall Center Operations conducted "Home Security" presentations for approximately 1400 personnel throughout the Center. As a result, we have increased the awareness and protection for our employees outside the workplace.

Property Accountability

In FY 1999 the property management processes were reengineered and improvements developed. This process improvement led the way to improve property accountability at MSFC in FY 2000. To educate users of their property responsibilities, a web-based training program was developed and provided to all MSFC and contractor employees. With the web-based training program, MSFC saved 3,150 employee hours and trained 6,500 personnel in 23 workdays; a 99% response rate. Annual inventories (versus tri-annual) were instituted, partnering with Center contractors. A property support assistant program was created to assist users in their property responsibilities. This Centerwide property awareness campaign has provided MSFC a more streamlined and accurate property accountability program.

MSFC Just-In-Time (JIT) Desktop Administrative Supply System

Center Operations implemented the pilot program for the new Web based ordering system to purchase office supplies. The system allows representatives from each organization to electronically order office supplies to be delivered directly to the requestor's desktop. This system also allowed for the closure of the office supply annex. Three organizations participated in the pilot program. The entire Center began using the system January 1, 2001.

Disposal Operations

In FY 2000 the MSFC Disposal effort was added to the Institutional Services Contract. The Disposal Team, consisting of contractor and civil service employees, processed over 10,000 pieces of excess equipment. The Disposal Team performed and completed testing on the NASA Property Disposal Management System (NPDMS) before it went into production. The team also trained all applicable personnel to properly utilize the complete functions of NPDMS with no added cost to NASA. NPDMS brought MSFC on line with the other NASA Centers and gave the General Services Administration (GSA) visibility of the excess equipment at MSFC. This new team benefits MSFC and a large network of federal, state, public, and private groups throughout the South.

Critical Hardware Moves

In FY 2000, the Marshall Center Operations Directorate supported moves of program critical hardware (PCH). These moves included onsite as well as offsite moves via the NASA Super Guppy. The *International Space Station* (*ISS*) oversized hardware included the S1 truss flight article, the P1 truss flight article, the airlock flight article, the truss structural test articles (S1, P3, P4) and the node structural test article. Also, some

smaller payloads were moved for the *ISS*, including the Vapor Compression Distillation Flight Experiment (VCD FE).

Pollution Prevention

The Toxic Chemical Release Inventory (TRI), reported in July 2000, confirmed that MSFC achieved a goal of reducing its top five reportable chemicals by 50 percent. Executive Order 12856 required MSFC and other federal facilities to meet this goal before the year 2000. The goal was measured against 1994 baseline data. MSFC achieved its 50 percent reduction in both 1998 and 1999, as determined by the July 2000 TRI. This was primarily accomplished through pollution prevention (P2) projects involving MSFC's vapor degreasing operations.

MSFC spent the year 2000 restructuring its pollution prevention program and goals to comply with Executive Order (EO) 13148, "Greening the Government through Leadership in Environmental Management," which was signed on April 21, 2000. With EO 13148 as guidance, MSFC began developing an Environmental Management System, revising its Pollution Prevention Plan to reduce toxic chemicals by 10 percent per year and phase out ozone-depleting chemicals. Much work was also completed toward establishing a chemical pharmacy. The pharmacy will be centered around a "just-in-time" delivery system that MSFC has already implemented for office products.

MSFC worked with an environmental team funded by NASA Headquarters to research and identify potential pollution prevention opportunities at the Center. Several potential projects were identified and will be included in the new Pollution Prevention Plan.

MSFC also developed and unveiled an on-line pollution prevention training module available to all employees. This module was available for Earth Day activities in April 2000. The module also received an honorable mention award at the 2000 Florida Technical Communication Competition.

Environmental Assessments

Extensive evaluations and technical guidance were provided in support of the Propulsion Research Laboratory's engineering study. Technical support was also provided to various other projects such as X–37, Cryogenic Test Facility, C of F projects, and facility work requests.

Marine Operations

In an effort to improve the safety and reliability of Shuttle booster recovery and External Tank barge towing operations, Center Operations conducted several reviews of the booster recovery ships' operations, maintenance, and contingency plans. This review included ships' surveys, observation of operations, and documentation reviews. As a result of these reviews, additional contingency plans were generated, contributing to the continued reliability of the ships for booster recovery and barge towing operations. These reviews also identified areas onboard the ships where additional maintenance was needed, contributing to the ability of the two original ships to operate through the forecast end of the Space Shuttle Program.

Superfund Cleanup

The Comprehensive Environmental Response Compensation and Liability Act (CERCLA) program at MSFC this year primarily focused on the areas of interum clean-ups, completing the characterization of groundwater contamination areas, and implementing pilot test studies to evaluate in-situ technology capabilities.

Two groundwater contamination source areas were selected to evaluate the potential for zero valent iron to reductively dechlorinate trichloroethene into harmless byproducts such as gaseous ethene, ethane, and carbon dioxide. One groundwater contamination area was selected to evaluate the potential for hydrogen peroxide to oxidize trichloroethene into carbon dioxide and water.

A fish harvest was conducted at a pond in the east test area (CERCLA Site MSFC-009). PCB contaminated fish were harvested and disposed of accordingly. The risk associated with the fish was ecological in nature (not human health) in that birds and other animals prey on the fish and can transfer the PCBs throughout the food chain. By harvesting the fish, the source of PCBs that could spread through the food chain has been eliminated.

Cleanup at a group of sites known as Operable Unit 9 were finalized in May 2000. The Record of Decision, which was concurred by the Environmental Protection Agency and the Alabama Department of Environmental Management, calls for no further action at these sites.

Onsite Medical Services

In order to support a safe and healthy work environment, MSFC civil service personnel and onsite contractors were provided access, as dictated by the parameters of their jobs, to physical examinations, special screenings, immunizations, first aid and emergency assistance. During FY 2000, over 11,000 patients received services at the MSFC Medical Center.

FY 2000 Construction of Facility (CoF) Program

All projects for which funding was received in the first quarter of the fiscal year were awarded in the first quarter. This met a very challenging performance metric established by NASA Headquarters reflecting the dedication and hard work of the Facilities Engineering Department design and construction group. In addition, close management of the overall program resulted in the opportunity for the Center to receive approval and funding for three additional projects.

MSFC Wellness Center

In April 2000, Facilities Engineering Division was given the task to plan and design a new Wellness Center for MSFC. The concept was based on the relocation of two fabric structures (that were purchased and temporarily installed near Building 4752 to house two major functions that MSFC hosted) to a permanent site at the northwest corner of Digney and Morris Roads. The project approval document was signed and funding of $900K released in May 2000. The design for the new 32,000 square foot Wellness Center was completed in August 2000, and the first phase construction contract was awarded on September 29, 2000. The design will incorporate the two fabric structures connected by a central facility housing changing areas, lockers, and showers.

Central Chilled Water Facility

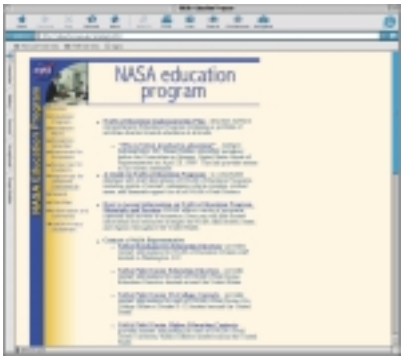
The third and last phase of a $20M Central Chiller Facility was completed in August 2000. The project installed approximately 60,000 feet of high-density polyethylene piping by six large pumps located at the chilled water plant. The change over of buildings from the old to the new system was made with no impact to the building occupants. The project was needed to comply with legislative requirements to reduce energy consumption and to phase out the use of old refrigerants. The project was completed within the established budget and schedule constraints.

Central Air Station

Activation of the Center's new central air station (Building 4607) was completed during this fiscal year. All compressed air operations including high purity air, wind tunnel air, and shop air are now provided from this central air station. All satellite air stations that supported these operations in the past have been taken out of service. The activation of this air station not only helped save energy, but also resulted in considerable operational cost savings for the center.

Agencywide Educational Support Activities

NASA's Education Homepage serves as the gateway for information regarding programs and services available to educators and students across the United States. Over 367 thousand electronic participants accessed the NASA Education Homepage during FY 2000, recording over 10.5 million "hits" and transferring 54 gigabytes of information.



NASA Central Operation of Resources for Educators (CORE) website provides the public access to more than 520 videocassette, slide, and CD-ROM programs, chronicling NASA's state-of-the-art research and technology.

During FY 2000, over 61 thousand electronic participants accessed NASA CORE, recording over 1.7 million "hits" and transferring 12 gigabytes of information.

NASA Spacelink is an electronic library that provides easy access to information on nearly all public NASA web sites as well as hosting electronic versions of NASA-developed curriculum support materials.

During FY 2000, over 1.26 million electronic participants visited Spacelink, recording over 52 million "hits" and transferring 369 gigabytes of information.

National Teacher of the Year program is a cooperative arrangement with the U.S. Space & Rocket Center to sponsor and host teachers from the U.S. and its territories at U.S. Space Camp. Additional NASA Marshall Space Flight Center support includes participation in an opening, closing, and graduation ceremonies, lunch and learn sessions featuring MSFC Senior Management, a tour of the Center, and several workshops at the Marshall Educator Resource Center.

Engineering Directorate Highlights

Vision:

"Engineering excellence enabling our customers' mission success."

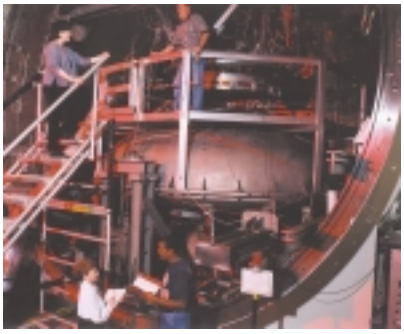
Mission Statement:

"In partnership with our customers and stakeholders, we provide engineering excellence in research, technology, development, and support essential to mission success and safety and built upon our core values."

Safety Commitment:

"MSFC Engineering Directorate will strive to prevent human injury and occupational illnesses and ensure safety of all operations and products"

The Engineering Directorate (ED) provides state-of-the-art engineering services for MSFC's product line directorates, enables safe and affordable access to space, and supports scientific investigations that broaden knowledge of the earth and universe. FY 2000 was a banner year for MSFC's Engineering Directorate, with significant accomplishments in providing quality products and services to our space transportation, flight projects and science customers. Space Transportation programs such as X-37, Second Generation Reusable Launch Vehicle (RLV), X-33/X-34, and MC-1 received innovative, yet highly accurate ED support in avionics integration, navigation and control hardware and software, cryogenic tank technology, design of specialized ground support tools for engine testing, and fabrication of composite combustion chamber and nozzles for engine systems. ED Departments also supported the International Space Station (ISS) and Chandra X-Ray Observatory, with highlights including environmental testing of the *ISS* Common Berthing Mechanism, structural and dynamic testing of the *ISS* Boeing Airlock and P3/P4 Truss element, materials compatibility testing of *ISS* hardware and components, computer software support for both the ISS Propulsion Module and the *ISS* Environmental Control and Life Support System, and Chandra electrical power system testing. Other FY2000 ED technical highlights were the first, full solar spectrum, high vacuum laboratory measurement of photon pressure on candidate solar sail material as well as the development of STORM, a new modeling tool used to enhance spacecraft-specific forecasting of Leonid meteor stream activity.



ED was actively involved in technology research and development in FY 2000. The Directorate provided considerable support to the Technology Transfer Office by developing new technologies for the Center Director's Discretionary

Fund program and relating to the Space Act Agreements. ED employees also were active in publishing and presenting scientific papers in trade journals and at technical conferences, respectively. Over 20 New Technology Disclosures were submitted by Directorate personnel, which led to the publication of five NASA Tech Briefs. A new fabrication methodology for lined composite tanks and a new densification processing method for carbon-carbon composites represent two of the many technological innovations that led to patents and awarded to ED personnel in FY2000. In addition, computer code generated by ED and used to analyze the thermal and flow parameters of fluid systems was released through the Technology Transfer Office. This code, version 3.0 of the Generalized Fluid System Simulation Program (GFSSP), is now available for commercial use. Two companies are currently negotiating with NASA for licensing.

This year, the Engineering Directorate also initiated an ongoing Independent Research and Development (IRAD) program. This program provides individuals or groups within ED the opportunity to conduct innovative research or technology development in technical areas relevant to ED's goals and objectives. The IRAD program also increases the Technical Readiness Levels of proposed technology developments within the Directorate and enhances the capability of ED to better support the MSFC product lines.

ED also participated in a number of technology outreach and teaming opportunities. In FY 2000, ED personnel organized the 4th Conference on Aerospace Materials, Processes, and Environmental Technology (AMPET) in conjunction with twelve government, academic, industry and societal entities including ASM International, Sandia National Laboratories, and the University of New Orleans. Also, a new partnership was established with Alabama A & M University for the development of silicon based radiation sensors. This year, the Cross Enterprise Technology Development Program approved a proposal involving ED personnel and the University of New Mexico to develop a miniature 1 mm2 ring laser gyroscope. ED's partnership with the U.S. Army Aviation & Missile Command was strengthened through increased efforts in the development and utilization of micro electro-mechanical systems. In FY 2000, the Army/NASA Virtual Innovations Laboratory (ANVIL) acquired and installed computer hardware and software necessary to create a virtual reality interface. Engineering designers use this virtual reality interface to examine component interactions and the effects of design modifications. This year, department members within the Directorate also teamed with others from Ames Research Center, Langley Research Center, Glenn Re-

search Center, Goddard Space Flight Center, and Dryden Flight Research Center to form the Project Reliance Manufacturing Co-op Team, to optimize manufacturing through innovation, teamwork, and cost-effective methods focused on customer satisfaction.

In FY 2000, the Engineering Directorate implemented new business and technical initiatives with the goal of improving both internal and external customer service. With the goal to shorten the internal design time cycle by at least 40 percent, members of ED led a multidisciplinary design and analysis effort. Based upon recommendations from this effort, a database tool was selected that facilitates the sharing of a master models between disciplines, effectively eliminating duplication of effort. ED also served as a "pilot" organization to implement the new NASA Integrated Technical Standards Initiative, a program designed to improve the engineering products and services provided by the Directorate. In another effort to enhance the utilization of ED technology based capabilities, the Engineering Technology Development Office compiled a "Yellow Pages" directory of current ED technologies. This directory will assist in future planning activities and enhance communication within the Directorate as well as with the MSFC product line directorates in relation to technology usage. Listed under alphabetized technology categories, the directory provides the names and phone numbers of the associated technology experts within ED. Also, in FY 2000, ED led the team responsible for developing MSFC's Insight Continuum Model. This model serves to mitigate program risks and enhance the probability of mission success by defining the responsibilities associated with increasing levels of NASA civil servant involvement.

Looking to the future, the Engineering Directorate developed a Strategic Plan in FY2000, which provides ED with a clear vision and direction for the next ten years. This plan, developed with the cooperation and teaming efforts of ED Department members and product-line representatives, defines the Directorate's Core Strategies for ensuring continued superior engineering excellence in the years to come.

FY 2000 Institutional Metrics and Performance

Center Operations Directorate

Ninety percent customer satisfaction by FY 2000

Mainframe computing has a customer satisfaction goal of 95 percent. For FY 2000, the satisfaction percentage averaged over 96 percent for eight customer feedback areas and was ranked by the NASA Chief Information Officer at a level of "Extremely Satisfied" in his report to Office of Management and Budget (OMB). NASA Integrated Services Network, WAN, has a high combined customer satisfaction rating and is expected to remain in the 90 percentile during FY 2001.

The NASA Automated Data Processing Consolidation Center (NACC) provided highly available (99.9 percent) and cost-effective mainframe computing systems for 15 different Agency workloads during FY 2000. Additionally, the FY 2000 Program Operating Plan (POP) cost projections for FY 2001 were 11.6 percent lower than the costs forecast for FY 2001 in POP 1999. Cost decreases for FY 2001 are directly attributable to continued standardization of hardware and software systems and support and replacement of old technology.

In FY 2000 Logistics Services completed the first full year of their customer satisfaction survey process. The results of the survey identified a customer satisfaction percentage of 4.8 (96%) out of a perfect 5.0 (100%) rating. This well exceeds the Center Operations goal of 90%. Measurement criteria are timeliness, courteousness, knowledge, quality, meeting needs, and safety.

The Facilities Engineering Department has a customer satisfaction goal of 95 percent. For FY 2000, a survey was conducted of approximately 33% of the Center. A satisfaction percentage of 96% was received. Customer Service Cards were left at each site where service was provided for trouble calls, facility work requests, etc. A 98% satisfaction rate was earned for FY 2000 as reported on these cards.

Ninety percent services provided at competitive rates by FY 2000

Information technology services benchmarked and offered at competitive rates during FY 2000 include applications programming support for both MSFC and the Agency, MSFC telephone and long distance services, cell phones and pagers (outsourced), NACC mainframe and midrange computing support, and services provided by the central reproduction area.

Logistics Services provides the Center with twenty-one services. Of the twenty-one, fourteen services can be compared to the commercial sector. Specialized services such as property support, mail, and permanent human capability cannot be compared in a competitive market. Of the fourteen services, ten were competitive prior to FY 2000, three were made competitive in FY 2000, and one is being monitored (travel services) to determine competitiveness. This is a 93% rating.

Perform annual building inspections and special inspections to ensure a healthy work environment

Logistics Services Department Manager performed routine inspections of buildings occupied by Logistics Services employees and contractor employees, to identify and correct hazards. Recommended corrective actions to any safety findings are tracked from initiation to closure.

Make available to all employees physical examinations, special screenings, immunizations, first-aid, and emergency assistance

All MSFC civil service personnel were provided access to physical examinations, special screenings, immunizations, first-aid, and emergency assistance during FY 2000. In addition, onsite contractors (as dictated by their jobs), received physical exams, special screenings, and immunizations. All contractors were provided access to emergency assistance services. During the last year, 11,425 patients were seen for exams and clinical visits.

Additional Center Operations Metrics

The goal for mainframe computing area system availability is 99.8 percent. In FY 2000, this availability goal was attained for all months except one where the system availability was 99.6 percent.

The goal of achieving a baseline Information Technology Security "basic" awareness training for MSFC civil-service employees was 95

percent in FY 2000. An aggressive training program was conducted and resulted in a completion rate of approximately 97 percent using both the provided CD-ROM and the SOLAR Web site.

The Environmental and Engineering Management Department exceed the 50 percent reduction of toxic chemical releases called for by Executive Order 12856 by 10 percent, and submitted all environmental assessment and impact statements on time to support program requirements.

The Toxic Chemical Release Inventory (TRI), reported in July 2000, confirmed that MSFC achieved a goal of reducing its top five reportable chemicals by 50 percent. Executive Order 12856 required MSFC and other federal facilities to meet this goal before the year 2000. The goal was measured against 1994 baseline data. MSFC achieved its 50 percent reduction in both 1998 and 1999, as determined by the July 2000 TRI. This was primarily accomplished through pollution prevention (P2) projects involving MSFC's vapor degreasing operations.

NASA's Integrated Services Network services exceeded the overall availability goal of above 99.5 percent for the year. Availability can be expected to remain at or above those levels for FY 2001. In FY 2000, NISN received 886 service requests and completed 788. In FY 2000, NISN supported 4,260 videoteleconferences, 63,033 voice teleconferences, and 310,534 broadcast fax pages.

Customer and Employee Relations Directorate

Implement IFMP Performance Series Training 3 months prior to IFMP implementation.

IFMP implementation was delayed due to contractor problems and therefore, IFMP Performance Series Training was not initiated in FY 2000.

Reduce the MSFC civil servants FTE while maintaining a diverse workforce.

Four months into the fiscal year, NASA ended its downsizing initiatives, and the emphasis changed from reducing FTE to launching a hiring effort. Consequently, the Center's net number of FTE increased by 55, while the Center's goal of maintaining diversity in the workforce was achieved.

Enhance public knowledge of MSFC programs by conducting a national media campaign monthly.

Media Relations more than doubled the goal of one national media campaign a month by conducting 27 national campaigns in FY 2000.

Increase the number of NASA Educator Resource Centers to seven in our six-state geographical region.

The metric of establishing a seventh Educator Resource Center (ERC) in MSFC's six-state service region will not be met. NASA Headquarters (Code FE) will no longer support two ERC sites in Alabama due to reduced program funding. Only the ERC site at the U.S. Space & Rocket Center will be supported and not a second planned regional site in Montgomery, Alabama.

Increase the employee and organizational development opportunities by 15 percent.

The Employee and Organizational Development Department significantly increased training for all employees during FY 2000. As the Center's workforce continues to welcome new challenges and opportunities so does this department. As the agency lead center for the NASA training database-AdminSTAR and Electronic Meeting System (EMS), the department continues to lead the way in creating a culture for change for the Center. The department will soon lead the way in the rollout of the web-based version of AdminSTAR.

The department also facilitated and supported many various Center special events and activities during the period, as well as implementing and coordinating several Center and agency-wide training initiatives such as the Safety and Health 2000 training program, ISO 9000 certification, Information Technology (IT) security, and web-based property accountability awareness training of all employees. Marshall's conference and symposia attendance registrations rose by more than 15% over the previous years participation levels (700 more instances).

Recruiting for Marshall's cooperative education program was revived and 15 new student trainees were added to Marshall's rolls. Organizational

development activities such as teambuilding workshops, and associated follow-on efforts, organizational strategy development retreats (over 150 conducted) were greatly expanded. Participant rates of the academic studies programs (i.e., full- and part-time studies), NASA engineering training, Fellowship programs, and Academy of Program and Project Leadership (APPL) training programs were also increased. The Incentive Awards program continued to reinvent itself, and several innovative award and recognition programs were held to reward the Center's most valued resource, its' people.

Implement summer program for college undergraduates and first year graduate students.

Program plans for a summer undergraduate program were developed for implementation in 2001.

Establish 10 new partnerships that compliment Marshall's primary mission areas; negotiate 3 new licensing agreements that provide monetary value to the Center; and release 10 new success stories that highlight the technologies of MSFC.

In FY 2000 the MSFC Technology Transfer Office established 34 new partnerships, negotiated 6 new licensing agreements, and released 16 success stories related to MSFC technology development.

Increase by 50 percent the number of key stakeholders briefed on MSFC's roles and missions with a focus to members of Congress on NASA oversight committees.

Four U.S. Senators, 12 U.S. Representatives, 103 Congressional staffers were briefed on MSFC's roles and missions both at the Center and off site. This is nearly a 350% increase from the previous FY. Also 4 Governors and 422 state and local elected officials were briefed.

Increase by 50 percent the number of speaking opportunities for the Marshall Director and other Center employees at the local, regional, and national level. With other Customer and Employee Relations Directorate organizations, develop key center messages on MSFC roles and missions for speakers to convey.

A 40 percent increase in speaking opportunities was provided to the Center, with approximately 21,000 people attending the briefings. Key Center messages for speakers were developed.

Incorporate exhibits and interactive displays at the Space Station bus tour stop about Marshall product lines by December 1999.

Exhibits showcasing Marshall space science, microgravity, and biotechnology research were included in the bus tour at the International Space Station mockup area.

Develop new methods of directing web surfing educators and students to NASA sites containing popular content sought by the educational community.

NASA Spacelink enhancements during FY 2000 include the creation of an On-line Educational Activities area which highlights topics of interest to educators with related links to relevant Spacelink content; and the Alphabetical Index, which allows quick searches of content by title.

Equal Opportunity

Strive for representation in all grade and organizational levels and occupational skill groups.

In FY 1998, an analysis of the Center's workforce was conducted for professional, administrative, technical, and clerical categories. The analysis revealed an underrepresentation of minorities in several areas as compared to the civilian labor workforce. An update conducted at the end of FY 2000 showed improvement primarily due to the hiring of a small number of minorities.

Provide fully-accessible facilities.

As individuals with disabilities are hired or have specific needs, reasonable accommodations are provided. These accommodations include equipment for vision, physical, and hearing impairments. All renovated and new construction is in compliance with Uniform/Federal Accessibility Standard, Americans with Disabilities Act (ADA), and with Section 504 of the Rehabilitation Act of 1973. During this reporting period, buildings were modified on an as-needed basis. Cell phones were provided for three employees with disabilities to call for assistance in an emergency. The buddy system where employees look out for and assist individuals with disabilities was re-emphasized. Motorized carts were provided for two employees for use at the Center. Approximately 30 Marshall Center employees participated in Level One American Sign Language training to enable them to communicate with hearing-impaired colleagues. The EO Office sponsored the "Windmills Attitudinal Training Program" focusing on attitudes and human factor regarding employees with disabilities at the Marshall Center.

Increase research opportunities with historically black and other minority universities.

The Marshall Center is strongly committed to continuing its links with minority universities and colleges and has aggressively and enthusiastically complied with the White House Initiative to advance the development of human potential at historically black colleges and universities (HBCUs), hispanic serving institutes (HSIs), and other minority universities (OMUs) through its science and engineering programs. The number of Agency-wide programs managed by MSFC decreased from eight to seven during FY 2000. Funding for minority institutions managed by MSFC was $10,107,419. The number of summer scholar interns from minority universities increased from 35 to 65 in FY 2000. The Center funded a local minority scholars program for 15 students at Oakwood College, Alabama A&M University, and the University of Alabama in Huntsville.

Financial Management

Obligate 95 percent of authorized funding for the current Program Year.

In FY 2000 97 percent of authorized direct funding for FY 2000 was obligated.

Cost 70 percent or more of the resources authority available to cost within the fiscal year.

In FY 2000 83 percent of the authorized direct funding for FY 2000 was costed.

Ensure that the IFMP Phase 1 systems and processes are successfully implemented 8 months after the successful test of the Core Financial Module.

The IFM software originally contracted for was never accepted by the Agency-led test team due to excessive defects and failure to meet requirements. As a result, NASA ceased testing of the software in March of 2000. Therefore, the IFM project never reached the trigger-point for the eight-month implementation phase that is referred to by this metric. Since March 2000, the IFM project has been completely restructured and a new IFM program office has been created. A formal Program Commitment Agreement (PCA) was signed for the new program on September 25, 2000. Under the new IFM program, MSFC will manage the Core Financial Project and the Integration Project.

Legal

Ensure that all court-imposed filing dates are met.

The Office of Chief Counsel supported a very active litigation workload in FY 2000. All court-imposed filing dates were met. Summary judgment motions were used effectively to reduce the amount of time that MSFC personnel needed to spend in court proceedings. Alternative dispute resolution mechanisms were utilized effectively to speed resolution in contract-related litigation.

Review financial disclosure forms within 60 days of submission.

Many MSFC personnel are required to submit financial disclosure reports annually. In FY 2000, 679 employees submitted confidential financial disclosure reports (OGE Form 450) and 64 employees submitted public financial fisclosure reports (SF278). These reports, which are required by Federal law, are useful in identifying and resolving potential conflict of interest problems. Legal review was accomplished on all financial disclosure reports within 60 days of their submission. In addition, web-based or live ethics training was provided to those personnel who were required to submit the financial disclosure reports and to other interested personnel.

Procurement

Increase obligated funds available for performance-based contracts to 80 percent.

MSFC achieved 88 percent for performance-based contracts.

MSFC will award 20 percent of its budget to small business concerns in FY 2000.

MSFC achieved 22 percent for small business concerns in FY 2000.

MSFC will award 8 percent of Its budget to small disadvantaged business concerns in FY 2000.

MSFC achieved 9.9 percent for SDB concerns in FY 2000.

Systems Management Office

Establish collaboratively with other MSFC and NASA organizations the expected mode(s) of interaction (e.g., customer, provider, peer) and document these in Systems Management Office (SMO) processes in FY 2000.

The Independent Program Assessment Office (IPAO) and MSFC SMO drafted a Memorandum of Understanding (MOU); electronic surveys of 41 MSFC personnel conducted and results analyzed to determine SMO modes of interaction with

major Center organizational elements; currently planning feedback meetings with major center organizational elements. Collaborated with the Independent Program Assessment Office located at Langley Research Center to establish a cost analysis steering group to promote consistency across the Agency in the cost estimating and analysis process.

Establish criteria in early FY 2000 for MSFC projects and programs to achieve focus status, a subset which receives the highest level of SMO support; and establish baseline Organizational Issuances through the MSFC ISO9000 management system that define SMO processes by January 1, 2000.

SMO focus defined to be Provide Aerospace Products and Capabilities (PAPAC) programs/projects reporting to MSFC Program Management Council per MPG 7100.1; three (100%) SMO Organizational Issuances baselined by November '99.)

Plan, conduct and support Independent Assessments and Independent Annual and Non-Advocate Reviews, as appropriate (30 planned); implement periodic independent evaluation to the MSFC Director (30 planned); and recommend project unique tailoring of 7120.5A processes.

11 NAR's/IAR's were performed/supported for FY 2000. This fell short of target, but target was too aggressive given start-up phase of SMO in FY 2000. Methodology for periodic independent evaluations to MSFC Center Director validated, and eight projects were evaluated monthly during pilot period. However, SMO was subsequently relieved of this responsibility by MSFC Center Director in favor of having projects report directly. Project-unique tailoring support provided to 26 projects.

Provide program and project planning consultation to projects in formulation to ensure NPG 7120.5A compliance (12 planned).

Provided consultation to 26 programs/projects during FY 2000, including cost analysis support.

Support MSFC implementation of the NASA Engineering Excellence Initiative, leading formulation of systems engineering training plans by September 30, 2000; and develop and implement process for mentoring of systems and cost engineers at MSFC by September 30, 2000.

NASA Engineering Excellence Initiative never formalized, hence support to MSFC implementation was not necessary. MSFC SE training and mentoring plan was developed, and a plan is currently under review for implementation by stakeholder organizations within MSFC. MSFC program/project mentoring plan implemented, wherein veteran project managers who are highly respected in the project management field are made available to MSFC program/project managers for consultation and advice. 14 MSFC projects benefited from this consultation service during FY 2000.

Implement prototype capability for ISE Reusable Space Transportation System (RSTS) application.

RSTS requirements definition complete. CWC's approved between SMO (ISE Project Management) and TD (performing organization) for this task documenting milestones, deliverables, and funding requirements; funding received from ISE Program Office in February 2000, and was subsequently returned to ISE at their direction in June 2000 before substantial progress was realized. Successfully integrated the NASA/Air Force Cost Model (NAFCOM) into the MSFC Concurrent Engineering Center and supported several reusable space transportation systems analyses.

Engineering Directorate

Complete benchmarking of engineering capabilities and identify areas for improvement.

Benchmarking using the National Research Council methodology was completed. Also, ED visited Johnson Space Center and Kennedy Space Center for benchmarking purposes.

Increase the relative amount of training by 10 percent compared to the FY99 baseline.

The total number of training hours logged with the training office for ED increased from 12,052.5 in FY99 to 16,110 in FY 2000.

Initiate at least one new means of communicating directorate information to ED personnel.

The website, "Ask ED" was implemented so employees can directly and anonymously provide input to ED management. Each submission is specifically addressed and both the employee's comment and the response is posted.

Achieve 90 percent customer satisfaction as determined by ED customer surveys of MSFC product line directorates and offices.

In interview and web-based customer satisfaction surveys, 91 percent of the respondents

reported that they were very satisfied, satisfied or neutral with respect to ED's services. Additional surveys that specifically addressed satisfaction with our strategic plan for the future showed 98 percent satisfaction.

Initiate at least one new means of obtaining customer feedback to ED from the product line directorates and offices.

ED initiated and performed customer focus surveys.

Reduce relative lost time injuries by 50 percent as compared to FY99 baseline.

The number of incidents that resulted in injuries increased from four in FY 1999 to six in FY 2000. However, the total number of incidents that resulted in lost time, an injury or a close call, or property damage was reduced from 15 in FY 1999 to 11 in FY 2000. Additional training implemented through Health and Safety 2000 and the Voluntary Protection Plan is planned for FY 2001.

Increase the relative number of ED technical memoranda, conference papers, and journal papers as well as ED membership in technical committees by 10 percent as compared to the FY99 baseline.

In FY99 ED personnel cleared 69 technical papers, one NASA Tech Brief and published 20 formal series reports. In FY2000, ED personnel cleared 128 technical papers, six NASA tech briefs and published 26 formal series reports.

Implement the NASA Engineering Excellence Initiative through responsibilities as Principal Center.

The NASA Engineering Excellence Initiative was discontinued, in lieu of the Systems Engineering Working Group (SEWG). The SEWG is being led by Orlando Figueroa, Deputy Chief Engineer for Systems Engineering out of HQ/Code AE. The SEWG has the charter to develop, document, and help establish a common framework for the engineering of NASA systems.

Establish at least three new teaming arrangements with another NASA Center(s) to support MSFC product line directorates and offices.

In FY 2000 ED teamed with Ames on the Advanced Computational Technology Team (ACTT) and with multiple Centers on the Orbiter Upgrade Corona Team. Also, ED20, ED30, and TD70 Cryotank experts worked with their counterparts at Langley Research Center to produce an integrated road map for Cryotank technology. In addition, Memorandum of Agreements (MOA's) were executed with the Army Aviation and Missle Command (AMCOM) and the Tri-Lateral Alliance (Oak Ridge Department of Energy, Arnold Engineering Development Center, MSFC) to enhance performance at each of the respective partner's sites, encourage transfer of technical knowledge and expertise, and optimize use of government facilities and assets.

Establish at least three new teaming arrangements with an industry and/or a university partner to bid on a NASA MSFC activity or NASA NRA's.

In FY 2000, ED teamed with Johnson Space Center, Langley, Boeing and Wright Research Labs to design and fly a demonstration platform in low earth orbit for testing and evaluating the performance of spacecraft materials. ED cryotank experts also teamed with industry as they wrote proposals for many different technical disciplines for NRA8-30 "Risk Reduction Technologies for 2nd Gen RLV." Task agreements were written with Boeing, Lockheed Martin, Alliant Tech Systems, Griffon Aerospace and Northrop Grumman. In addition, a Space Act agreement with Boeing to support Boeing Automated Vehicle Operations (AVO) development was executed. Also, a partnership with Science Applications International Corporation (SAIC) was established to meet the Defense Advanced Research Projects Agency (DARPA) orbital express request for proposal. AERO Astro/SAIC/MSFC was one of three winners.

Initiate and/or propose at least one new national or international activity for ED to lead the Agency in a crosscutting engineering function.

ED's NASA Operational Environment Team (NOET) signed an MOA with HQ designating MSFC as Agency lead for the Clean Air Act (CAA) regulations to support and assist Headquarters Code JE, in the management of NASA's review of EPA-proposed CAA regulations that may impact NASA program hardware and supporting facilities.

Increase the relative number of ED patent disclosures by 20 percent as compared to the FY99 baseline.

In FY99, ED personnel had three patents issued and two patents filed. In FY 2000, ED personnel had 5 patents issued and five patents filed.

Participate in the transfer of at least two new technologies into the private sector.

ED personnel made 21 new technology reports in FY 2000. In FY 2000, Friction Stir Welding was one technology transferred to the private sector by ED.

Outreach Activities

Sharing Our Story, Creating New Opportunities

An important part of the Technology Transfer Department's program is to inform potential customers about the ways that the Marshall Center and NASA serve the space community and American industry and academia. The activities designed to provide this knowledge are grouped under the umbrella of Technology Outreach.

During FY 2000, presentations were made at 28 technical conferences/events with a combined attendance of more than 220,000; more than one million hits were recorded on the Marshall Technology Transfer web site; six technology fact sheets were produced and distributed; eight new technology opportunity sheets were produced and three were updated; six publications were produced; "Small Business School," a Public Television series, spotlighted a Marshall partnership; 10 SBIR/STTR success story charts were produced; and 23 articles were contributed to trade magazines highlighting technology.

Answering a challenge from NASA Administrator Dan Goldin for more outreach opportunities within the Tennessee Valley Corridor, Marshall's Technology Transfer team played the lead technical role in the first in a series of workshops to feature federal agencies within North Alabama, middle and Eastern Tennessee and Western Virginia.

Science Communications

The past year was an excellent year for the MSFC science communications process and the Science@NASA family of websites. All of the Science@NASA websites showed an increase in readership in 2000. Total number of hits (items that were downloaded from our server to a customer) for all sites was 329,000,000. The total number of visits (defined as consecutive pages downloaded from our server to the same internet address within a 15 minute period) was 29,800,000. Visits can be loosely correlated to individuals coming to a site and downloading information. (See Fig. 2)

Story production for year 2000 on SNG included 183 stories for our main site. Our stories covered all NASA enterprises. Of these 183 stories, 26 were recast to high school and middle school levels and published on our Liftoff and NASAKids sites. An additional 13 stories were published solely for NASAKids and Liftoff.

The new spanish NASA science website Ciencia@NASA (http://ciencia.msfc.nasa.gov) debuted in November. This is NASA's first hispanic web presence dedicated to the whole of NASA research. A service of english science stories in audio as well as written format was begun on SNG.

The Thursday's Classroom educators' site presented 24 episodes of lesson plans and classroom activities based on our NASA science stories in 2000. During 2000 we began to tie the Thursday's Classroom topics not only to a NASA science theme but to the American Association of Advancement of Science (AAAS) "Benchmarks for Science Literacy-Project 2061" guidelines

The individual sites registered hits/visits in 2000 as follows:

- **http://science.nasa.gov (SNG)**
  94,000,000 11,100,000 (adult science content)
- **http://liftoff.msfc.nasa.gov**
  166,000,000 13,000,000 (high school and adult science content)
- **http://kids.msfc.nasa.gov**
  32,000,000 1,700,000 (middle school science content)
- **http://www.thursdaysclassroom.com**
  6,700,000 774,000 (classroom exercises and lesson plans)
- **http://www.spaceweather.com**
  30,000,000 3,300,000 (focused adult science content)

Fig. 2

Science@NASA began experimenting with realtime audio transmission to the web of various atmospheric and astronomical "songs!" This will become a feature presentation of our service in 2001. Visitors will be able to listen to whistlers from Earth's ionosphere, pings as meteors crash through our atmosphere, and "music" from storms in Jupiter's magnetosphere.

Socioeconomic Programs

The socioeconomic program is a function within the MSFC Procurement Office. This office plans, implements, and administers the small business activities, generally referred to as socioeconomic programs. The objective is to be an advocate for business opportunities for all business types while fostering contracting diversity. During FY 2000, MSFC achieved its goals. The Center Implementation Plan metric is 20 percent of obligations with Small Business and 8 percent with SDB. The achievement was 22 percent and 9.9 percent respective. Specific goal attainment was: small business direct 105 percent of goal; SDB direct 117 percent; Section 8 (a) program 127 percent; woman-owned small business direct 130 percent, subcontracting SB 118 percent, SDB subcontracting 155 percent and woman-owned subcontracting 171 percent.

Initiatives of the year included continuation of the Suppliers Street Markets, supporting nine trade shows, one congressional briefing, and the awarding of 11 new Small Business Association (SBA) Section 8(a) contracts. The extensive outreach effort continued with 678 in-office counseling sessions to businesses, 3,800 telephone sessions, and 1,600 e-mail sessions.

Marshall Center Involvement in the Educational Community

Our education mission is to use NASA's unique resources to support educational excellence for all. The Marshall Center has always placed a high priority on education, both with students in the community, throughout the country, and with our employees. Our support of the educational community is looked upon as an investment in America's future. The Marshall Center's educational programs endeavor to support and facilitate the educational community by providing content and services which furnish access to and meaningful involvement in NASA missions and consequently its achievements. We involve the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds. These efforts are directed toward ensuring the continued availability of scientists and engineers required to preserve our leadership in aerospace science and technology.

During FY 2000 the Marshall Space Flight Center sponsored their "first" team to compete in the FIRST Robotics Competition. FIRST (For Inspiration and Recognition of Science and Technology) is an annual event with the mission to generate an interest in science and engineering among students. Lee High School's winning proposal resulted in a grant from Marshall's Education Programs Department. The MSFC team of Lee High School students, parents, and teachers from Huntsville, Alabama; worked with engineers from MSFC, faculty and students from the University of Alabama, Weddendorf Design, Mevatec Corporation, and numerous other contributors to brainstorm, plan, design, construct, and test their "champion" robot. The students and their space program partners had results to show for their effort. At the regional competition held in Houston, Texas, MSFC-sponsored Lee High School won the "Judges' Award." The team also walked away with two more awards at the national competition held in Orlando, Florida: "Getting it Right" and "Highest Score in a Single Match."

In February 2000, a nationwide audience of almost 100,000 educators and five million students watched the first Marshall-produced NASA CONNECT television program titled, "Proportionality: The X-Plane Generation." NASA CONNECT is an integrated math and science series of instructional video programs for upper elementary and middle schools. NASA CONNECT supports the national math and science standards, is

accompanied by a teacher's guide, includes a classroom activity or experiment, and contains a Web-based technology component.

The video, featuring NASA researchers and other professionals who described scientific concepts, focused on ratio, proportion, scaling, measurement, and systematic investigation. The program showed students how proportionality and ratios are used to make small-scale versions of spacecraft and that scale models are more manageable than full-scale models when it comes to testing and retesting designs. Educators and students from Talladega, Alabama, were featured in the program's Web-based, technology component which offered activities centered on the construction and test flying of paper airplanes. The challenge for the Talladega students was to build one of the paper airplanes to a larger scale. The activity provided students with practical experience and questions involving ratios and proportions while introducing the unique problems engineers face associated with scaling.

Informing and Educating NASA's Stakeholders

The Government and Community Relations Department oversees the operation of a comprehensive integrated liaison activity for the Marshall Center to local, state, and federal elected officials, community leaders, and contractors and their professional associations. This office develops and disseminates informational material to select elected officials on a consistent basis in order to enhance and promote interest in MSFC missions, and programs. In addition, the Government and Community Relations Department serves as the main interface with the public and public facilities. Through services such as the Public Inquiries Office, the Speakers Bureau, the Freedom of Information Act, and community based outreach efforts, this office strives to keep the public informed about Marshall's vital roles and missions within NASA.

Many special events on and off the Marshall Center, are held to promote understanding of Center capabilities, missions and programs. In FY 2000, this department spearheaded over 12 public events, and directed an employee night at a local professional baseball game. Further, the Government and Community Relations Department responded to Public Inquiries from the following media: 1565 letters, 2200 e-mail requests, and 452 telephone calls. Also, this office provided nearly 700 VIP packages to MSFC visitors. Additionally, responses were provided to over 230 Freedom of Information Act requests. This represented an increase in workload of 26% from the previous year. The Marshall Center hosted 207,500 people through the U.S. Space & Rocket Center bus tour on the Marshall site.

World Wide Web (WWW)

Visit the following web sites for additional information.
Other site listings can be found through the NASA/MSFC homepages.

The NASA Homepage:
http://www.nasa.gov

The MSFC Homepage:
http://www.msfc.nasa.gov

The NASA CFO Homepage:
http://ifmp.nasa.gov/codeb

The MSFC CFO Homepage:
http://cfoweb.msfc.nasa.gov/cfowww

NASA Education Program:
http://education.nasa.gov

MSFC Education Programs Homepage:
http://education.msfc.nasa.gov

NASA Central Operation of Resources for Educators (CORE):
http://core.nasa.gov

NASA Spacelink:
http://spacelink.nasa.gov

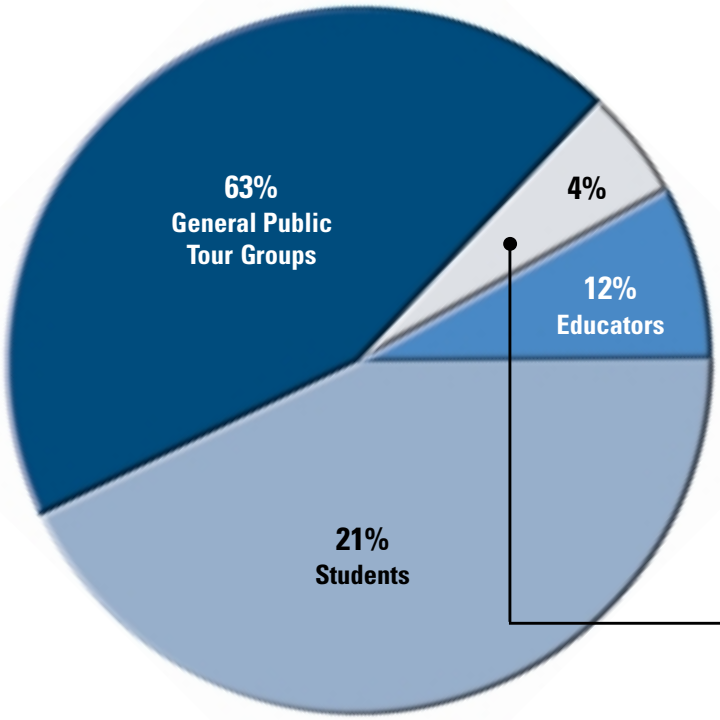
Liftoff to Space Exploration:
http://liftoff.msfc.nasa.gov

NASA Solutions—Technology Transfer:
http://nasasolutions.com

NASA Acquisition Internet Service:
http://procurement.nasa.gov

Science at NASA:
http://www.science.nasa.gov

NASA/Marshall Education Programs Department Total In-Person Involvement FY 2000



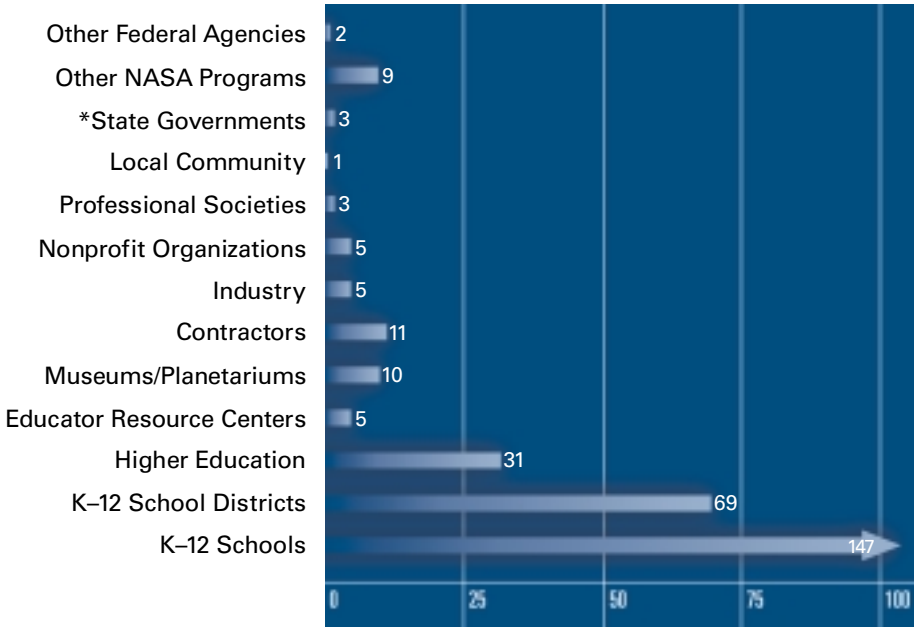
Total Participants:	**232,179**
Students	48,194
Educators	26,587
Educational Others	9,905
General Public Tours	147,493

NASA/Marshall Education Programs Department Participants' Ratings of Excellence FY 2000

	Average Rating	Number of Participants	Number of Programs Reporting
Program Staff Rating	4.84	722	12
Would You Recommend the Program to Others	4.84	590	12
Expect to Apply What Was Learned	4.58	873	15
Program Was a Valuable Experience	4.76	2,451	17

Strongly Agree/Excellent	5
Agree/Good	4
Neutral/Average	3
Disagree/Poor	2
Strongly Disagree/Very Poor	1

NASA/Marshall Education Programs Department
Number of Partnerships/Collaboration Incidents FY 2000

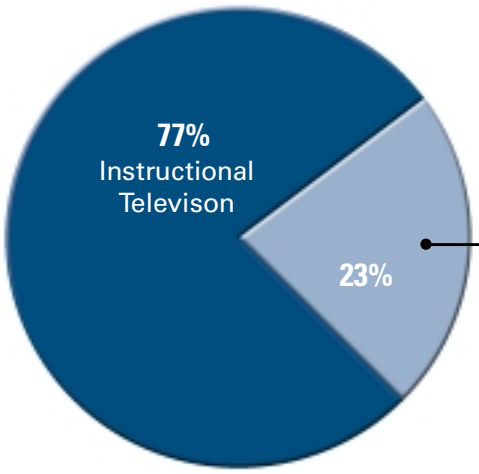


Total Incidents of Partnerships/Collaborations: 301

Total number of Programs Reporting: 22

*With participants from all 50 states

NASA/Marshall Education Programs Department
Total Electronic Involvement FY 2000



Total Participants: **9,004,535**

Unique IP Addresses: 1,738,433

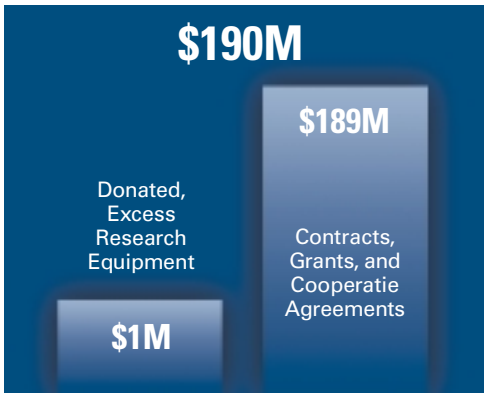
*Instructional Televison: 7,266,102

*Registered Viewers: 41,379 Educators and 7M Students

Unique IP Addresses From Educational Web Sites

NASA/Marshall Education Programs
Use of Resources FY 2000

Public K–12 School Districts	4
Post Secondary Schools	3
Universities, Colleges, and Non-profit Organizations	202



Marshall Center's Expenditures in Alabama

NASA Marshall Center Boosts Alabama Economy With $774 Million in Fiscal 2000 Expenditures

NASA's Marshall Space Flight Center in Huntsville, Ala., contributed $774 million to Alabama's economy in fiscal year 2000.

Included were $238 million in salaries for civil service personnel and related costs, as well as travel. Also included was $536 million spent on locally procured services, prime contractor and subcontractor support, and local construction. The $774 million spent in Alabama was significantly more than the Marshall Center's expenditures in any other state.

In addition, NASA funding of approximately $128 million was spent in North Alabama for International Space Station hardware development by The Boeing Company. Approximately $57 million funding was spent by MSFC on NASA programs where Marshall had a supporting role and an additional $43 million was spent on programs where Marshall performed work for other agencies.

Marshall received approximately 16 percent – or $2.2 billion – of NASA's total budget of $13.6 billion during fiscal 2000. Of Marshall's budget 73 percent was spent for Human Exploration and Development of Space including Space Shuttle and Space Station activities; 26 percent for Space Science, Earth Science, Aero-Space Technology and Biological & Physical Research activities; and about 1 percent was spent on Strategic Support of Marshall Center Programs.

Since it was established in 1960, the Marshall Center has had budget responsibility for more than $67 billion. When yearly figures are adjusted for inflation, this total is equivalent to more than $167 billion in today's dollar value.

Approximately $69 million in retirement annuities were paid in FY 2000 to 2,515 Marshall retirees residing in Alabama, with 1,604 retirees in Huntsville and Madison receiving $44 million of that amount. Through September 2000, the Marshall Center paid $5 billion in federal salaries since its creation in 1960. In FY 2000 MSFC civil service employees collectively paid more than $185 million in Federal Income Taxes and more than $6 million in Alabama State Income Taxes.

At the end of September, Marshall's permanent and temporary civil service employees totaled 2,676, including employees at resident offices at prime contractor facilities and at NASA's Michoud Assembly Facility near New Orleans, La.

Of that workforce, 2,195 were college graduates, with 1,450 holding bachelor's degrees. There were 165 employees with doctorate degrees and 580 with master's degrees in fields of engineering, science —predominantly mathematics and physics—as well as other disciplines, predominantly business administration.

During FY 2000 23,649 contractor personnel engaged in work for the Marshall Center, including 2,800 in mission support, 10,502 on prime contract work and 10,347 as subcontractors and vendors. Of the total, 6,980 worked in Alabama. Additionally, 763 contractors were associated with International Space Station work being done by Boeing in Huntsville and 730 jobs relating to other NASA work supported by Marshall.

During fiscal 2000, 305,079 people toured Marshall, including educators, conference and symposium visitors and news media. Of these, 203,223 toured the Marshall Center as part of the U.S. Space & Rocket Center's bus tour program. The Space & Rocket Center in Huntsville is Marshall's official NASA Visitor Center

Universities & Colleges:

In support of our nation's higher education institutions, the Marshall Space Flight Center in FY 2000 funded 164 universities and colleges within the 50 states. Of these 164 universities and colleges, there were 514 active research grants & training activities with a total contract value of $796 million. The total obligations against these grants and training contracts for FY 2000 totaled $127 million.

In the state of Alabama, MSFC funded 10 colleges & universities that held 107 active contracts. The total contract value equaled $137 million with a funded amount of $35 million for FY 2000. The universities & colleges in Alabama that were funded include: Alabama A&M University, Auburn University, Birmingham Southern College, Oakwood College, Trenholm State Tech College, Tuskegee University, University of Alabama in Birmingham, University of

Alabama in Huntsville, University of Alabama in Tuscaloosa and the University of South Alabama.

Non-Profit Institutions:

The Marshall Center also had 66 awards with non-profit institutions that totaled a contract value of $345 million across the 50 states. There were 38 institutions that held these 66 awards. A total of $62 million was funded to these non-profit organizations for FY 2000.

In the state of Alabama, MSFC funded 11 non-profit institutions that held 22 contracts, received $9 million in funding, with a total contract value of $32 million. The non-profit organizations in Alabama that received funding were: Alabama Dept Environment Management, American Institute of Aeron & Astro, ARC of Madison County, Business Technology Development Center, IIT Research Institute, Lee High School, NASA Exchange @ MSFC, North Alabama Science Center, Inc., Southern Research Institute, U.S. Space & Rocket Center, and Universities Space Research.

Combined Universities, Colleges & Non-Profit Organizations:

The Marshall Space Flight Center funded a total of $189 million on 202 universities, colleges and non-profit organizations throughout the United States for FY 2000. This amount of funding was placed on a total of 580 contracts.

Marshall supported the Graduate Student Researchers Program with 40 fellowships given to students whose research interests coincide with NASA's mission. Eight of these fellowships were granted to participants from universities in Alabama.

The Marshall Center's Cooperative Education Program included graduate and undergraduate students representing 9 colleges and universities in 3 states. Twenty-one participants came from 7 different Alabama colleges and universities. Additionally, there were five students participating in the program from Alabama technical schools.

The Center supported a Summer Faculty Program with 44 faculty fellows and 17 accompanying students spending part of their summer performing research at many of Marshall's laboratories. Twelve of these participants represented Alabama universities.

The Alabama Space Grant Consortium continued to provide leadership and form partnerships with other universities, government, and industry to better understand, develop, and use space resources through research, education, and public service functions. In fiscal year 2000, seven Alabama universities participated in the Consortium's activities and funding was increased to $486,875.

In 2000, more than 48,194 students and 26,587 teachers and faculty representing all 50 states were reached through the operation of Marshall's education programs. The Marshall Center donated $1 million in research equipment and placed some $189 million on grants, contracts and cooperative agreements through the education programs. Marshall employees and retirees volunteered to participate in the NASA Project LASER (Learning About Science, Engineering and Research) Program, serving locally as speakers, tutors, consultants, and science fair judges. During FY 2000, 5,466 educators benefited from 84,102 educational publications mailed from the MSFC Educator Resource Center located at the U. S. Space & Rocket Center. Additionally, over 9 million participants were touched by Marshall's distance learning initiatives during FY 2000.

An additional way Marshall gives back to the community is through the monthly Red Cross Blood Drives where 828 pints of blood were collected in FY 2000 from civil service and on-site contractors. Also, Marshall civil service employees contributed $505,268 to the Combined Federal Campaign – $288,288 of the total was designated to help agencies in Alabama.

The Marshall Space Flight Center celebrated 40 years of operation in FY 2000. Marshall looks to the future with dedication to continue its role as a vital contributor to America's future in space while positively impacting the local, state, and federal economy.

Overview of Financial Statements

MSFC's financial statements were prepared in accordance with Federal accounting standards. At present, MSFC follows the following hierarchy of accounting standards as required by the Office of Management and Budget (OMB):

a. Individual Federal Accounting Standards Advisory Board (FASAB) standards published by OMB, GAO, and Treasury.

b. OMB financial statement form and content guidance.

c. Agency accounting guidance which represents prevalent practice.

d. Accounting principles published by other authoritative sources.

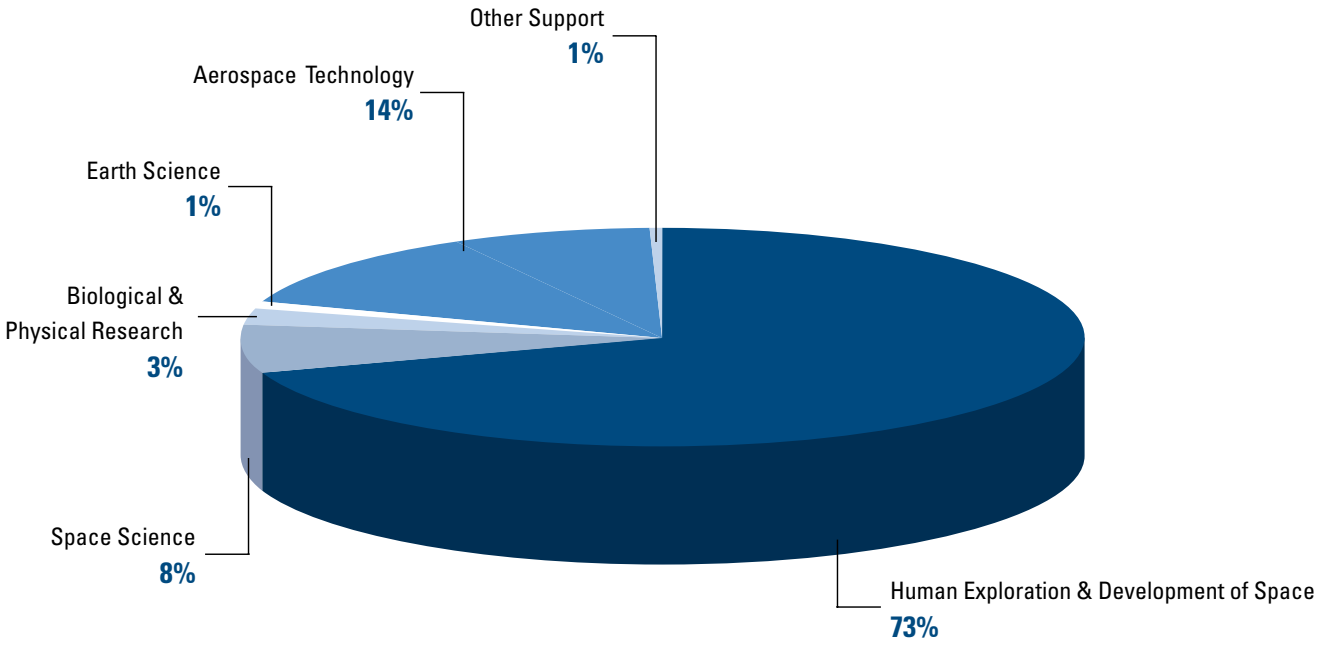
The financial statements include the Statement of Financial Position and the Statement of Operations and Changes in Net Position. These statements include all MSFC activities and 100 percent of the Center's budget authority. While the statements have been prepared from the books and records of MSFC, in accordance with formats prescribed by OMB Bulletin 94-01, the statements are different from the financial reports used to monitor and control budgetary resources which are prepared from the same books and records.

The statements should be read with the realization that they are for a component of a sovereign entity, that liabilities not covered by budgetary resources cannot be liquidated without the enactment of an appropriation, and that payment of all liabilities, other than for contracts, can be abrogated by the sovereign entity.

NASA's budget is funded by three appropriations. The Human Space Flight (HSF) appropriation provides funding for the International Space Station and Space Shuttle programs, including flight support for cooperative programs with Russia. The Science, Aeronautics and Technology (SAT) appropriation provides funding for NASA's research and development activities, including all science activities, global monitoring, aeronautics, technology investments, education programs, mission communication services, and direct program support. Funding for NASA's civil service workforce, space communication services, safety and quality assurance activities, and facilities construction activities, to preserve the Agency's core infrastructure, is provided by the Mission Support (MS) appropriation.

Beginning with the fiscal year 1995 budget, the HSF, SAT, and MS appropriations replaced the four appropriations that were previously used to fund NASA's activities. Those appropriations were Space Flight Control and Data Communications (SFCDC), Research and Development (R&D), Research and Program Management (R&PM), and Construction of Facilities (CoF). The fiscal year 2000 Center budget is presented below.

MSFC Budget by Enterprise ($M)



Total Funding
$2,218

Enterprise	$M	% of Total
Human Exploration & Development of Space	1,632	73%
Space Science	180	8%
Biological & Physical Research	62	3%
Earth Science	24	1%
Aerospace Technology	308	14%
Other Support	12	1%
MSFC Grand Total	**2,218**	**100%**

Source: FY 2000 Data—NASA Budget to Congress April, 2001.

Note: Civil Service Salaries and Travel Distributed by Enterprise.

MSFC Statement of Financial Position

As of September 30, 2000 (In Thousands)

	2000	1999	1998
Assets			
Intragovernmental Assets:			
Fund Balance with U.S. Treasury (Note 2)	$1,031,593	$1,051,564	$997,599
Accounts Receivable, Net (Note 3)	1,923	3,015	7,413
Advances and Prepayments	96	171	572
Governmental Assets:			
Accounts Receivable, Net (Note 3)	603	4	38
Advances and Prepayments	0	0	0
Cash, Imprest Fund	0	0	0
Operating Materials and Supplies (Note 4)	2,002	2,326	2,437
Property, Plant and Equipment (Note 5)	4,266,148	2,933,889	3,982,835
Other Assets (Note 6)	1,265,066	1,087,680	1,079,390
Total Assets	**6,567,431**	**5,078,649**	**6,070,284**
Liabilities			
Liabilities Covered by Budgetary Resources:			
Intragovernmental Liabilities:			
Accounts Payable	10,708	11,795	13,370
Other Liabilities (Note 7)	1,755	1,794	2,328
Governmental Liabilities:			
Accounts Payable	578,742	633,055	613,968
Other Liabilities (Note 7)	14,650	12,560	12,375
Total	605,855	659,204	642,041
Liabilities Not Covered by Budgetary Resources:			
Intragovernmental Liabilities:			
Other Liabilities (Note 7)	933	752	432
Governmental Liabilities:			
Other Liabilities (Note 7)	19,406	19,315	20,738
Total	20,399	20,067	21,170
Total Liabilities	**626,254**	**679,271**	**663,211**
Net Position			
Unexpended Appropriations	428,548	395,546	363,574
Invested Capital	5,533,023	4,023,895	5,064,661
Cumulative Results of Operations	3	3	0
Future Funding Requirements	(20,397)	(20,066)	(21,162)
Total Net Position (Note 8)	**5,941,177**	**4,399,378**	**5,407,073**
Total Liabilities and Net Position	**$6,567,431**	**$5,078,649**	**$6,070,284**

The accompanying notes are an integral part of these statements. These statements are for internal use and have not been audited.

Statement of Operations and Changes in Net Position

For the Year Ended September 30, 2000 (In Thousands)

	2000	1999	1998
Revenues and Financing Sources			
Appropriated Capital Used	$3,153,748	$3,256,665	$2,178,816
Revenues from Sales of Goods and Services:			
To the Public	1,273	50,696	13,750
Intragovernmental	36,905	(2,087)	8,596
Total Revenues and Financial Sources	**3,191,926**	**3,305,274**	**2,201,162**
Expense			
Program or Operating Expenses:			
Science, Aeronautics and Technology	1,140,71	1,485,329	504,403
Human Space Flight	1,685,558	1,391,050	1,258,506
Mission Support	327,758	379,833	413,048
Research and Development	(1,058)	182	1,217
Space Flight Control & Data Communication	468	(4)	(811)
Research and Program Management	0	(63)	0
Construction of Facilities	281	335	2,453
Reimbursable Expenses	38,178	48,609	22,346
Total	**3,191,926**	**3,305,271**	**2,201,162**
Excess (shortage) of Revenues and Financing Sources over Total Expenses	0	3	0
Nonoperating Changes			
Unexpended Appropriations	33,002	31,972	(74,001)
Invested Capital	1,509,128	(1,040,766)	(1,128,468)
Future Funding Requirements	(331)	1,096	2,840
Total NonOperating Changes	**1,541,799**	**(1,007,698)**	**(1,199,629)**
Excess (shortage) of Revenues and Financing			
Sources Over Total Expenses and Nonoperating Changes	1,541,799	(1,007,695)	(1,199,629)
Net Position—Beginning Balance	**4,399,378**	**5,407,073**	**6,606,702**
Net Position—Ending Balance	**$5,941,177**	**$4,399,378**	**$5,407,073**

The accompanying notes are an integral part of these statements. These statements are for internal use and have not been audited.

MSFC Notes to Financial Statements

For the Year Ended September 30, 2000

1 Summary Accounting Policies and Operations

The following notes represent integral disclosures to MSFC's finanacial statements.

Basis of Presentation

These financial statements were prepared to report the financial position and results of operations of MSFC, pursuant to the requirements of the Chief Financial Officers Act of 1990. The statements were prepared from the books and records of MSFC, in accordance with the comprehensive basis of accounting specified in OMB Bulletin 94-01, Formats and Instructions for the Form and Content of Agency Financial Statements.

Reporting Entity

MSFC is one of nine NASA Centers and Headquarters established to aid NASA in its mission to provide for aeronautical and space activities. Financial management of its operations is the responsibility of Center officials at all organizational levels. MSFC's accounting system is one of ten distinct operations located at nine NASA Centers and Headquarters. Although MSFC, like the other Centers, is independent and has its own Chief Financial Officer, it operates under Agencywide financial management regulations. MSFC provides payroll accounting Agencywide for approximately 19,000 civilian employees and processes approximately 50,000 nonpayroll-related accounting transactions monthly. This data provides the basic information necessary to meet internal and external financial reporting requirements and provides both funds control and accountability.

Budgets and Budgetary Accounting

Seven appropriations require individual treatment in the MSFC accounting and control system.

1. The HSF appropriation supports human space flight research and development activities for space flight, spacecraft control, and communications actions. This includes research, development, operations, services, maintenance, and construction of facilities which encompasses the repair, rehabilitation, and modification of real and personal property.
2. The SAT appropriation provides for the conduct and support of science, aeronautics, and technology. This includes research, development, operations, services, maintenance, and construction of facilities which encompasses the repair, rehabilitation, and modification of real and personal property.
3. The MS appropriation provides for safety, reliability, and quality assurance activities supporting Agency programs, space communication services for NASA programs, salaries and related expenses in support of research in NASA Field Centers, and construction of facilities which encompasses the repair, rehabilitation, and modification of real and personal property.
4. The R&D appropriation, which was restructured and replaced in the 1995 budget, includes research and development of aeronautics and space, space vehicles, space systems effort, related institutional activities, minor construction repair, maintenance, rehabilitation, and modifications.
5. The SFCDC appropriation, which was restructured and replaced in the 1995 budget, includes production, operations, and support activities for the Space Transportation System which includes the Space Shuttle and expendable launch vehicles and for tracking, telemetry, command and data acquisition support of all flight projects.
6. The CoF appropriation, which was restructured and replaced in the 1995 budget, includes the construction of new facilities and the repair, rehabilitation, and modification of facilities.
7. The R&PM appropriation, which was restructured and replaced in the 1995 budget, includes salaries, travel, and related expenses for the civil

servants in support of NASA programs.

In addition to the basic operating programs described above, MSFC expenditures for FY 2000 included $38 million of reimbursable activity.

Basis of Accounting

MSFC accounts are maintained on an accrual basis, where expenses and revenues are recorded in the accounts in the period in which they are incurred or earned. Expenses are classified in the accounts according to the appropriation that financed the activity. These expenses are coded in accordance with the Agencywide coding structure, which sets forth a uniform classification of financial activity that is used for planning, budgeting, accounting, and reporting. The expenses are further categorized in the general ledger as operating expenses or capitalized expenses.

Funds with the U.S. Treasury and Cash

MSFC's cash receipts and disbursements are processed by the U.S. Treasury. The funds with the U.S. Treasury include appropriated funds and deposit funds for advances received for reimbursable services.

Advances

MSFC funds its University Contracts and Grants program by recipient drawdowns on letters of credit or through the use of predetermined payment schedules where letters of credit are not used; recipients are required to schedule drawdowns to coincide with actual, immediate cash requirements, in accordance with OMB Circular A-125 and Department of Treasury regulations. Quarterly financial reporting of cash transactions is provided on Federal Cash Transactions Reports (SF 272's). Detailed monitoring and accountability records are maintained; monitoring includes audits by the Defense Contract Audit Agency (DCAA) and the NASA Office of Inspector General.

Accounts Receivable

The largest portion of accounts receivable is due from other Federal agencies and includes research and development of satellites as well as launch services. Nongovernment customers are required to provide advance payments which are placed on deposit with the U.S. Treasury until services are performed. In unusual cases, exceptions and waivers to this general rule have been granted under the Space Act, allowing customers to postpone advance payments.

The allowance for uncollectible accounts is based upon an evaluation of each individual accounts receivable, considering the probability of failure to collect based upon current status, financial and other relevant characteristics of debtors, and the relationship with the debtor. Under a cross-servicing arrangement, accounts receivable over 180 days delinquent are turned over to the U.S. Department of the Treasury for collection.

Prepaid Expenses

Payments in advance of the receipt of goods and services are recorded as prepaid charges at the time of prepayment and recognized as expenses when related goods and services are received.

Operating Materials and Supplies

IIn accordance with with Statement of Federal Financial Accounting Standards (SFFAS) Number 3, Accounting for Inventory and Related Property, materials held by MSFC which are repetitively procured, stored, and issued on the basis of recurring demand are considered Operating Materials and Supplies.

Property, Plant and Equipment

MSFC-owned property, plant and equipment may be held by the Center or its contractors and grantees. Under the provisions of the Federal Acquisition Regulation (FAR), contractors are responsible for control over and accountability for such property in their possession.

Property with a unit cost of $100,000 or more and a useful life of 2 years or more is capitalized. Capitalized cost includes all costs incurred to bring the property to a form and location suitable for its intended use, including acquisition, transportation, installation, handling, and storage costs. All other property is expensed when purchased.

MSFC has use of its land under a no cost, 99-year lease with the Department of the Army.

Government-owned/contractor-held property includes land, buildings, structures, materials, plant equipment, agency peculiar property, special tooling, and special test equipment. Contractors report each September 30 on a NASA Form 1018, Report of Government-owned/contractor-held property. This form is certified by the contractor's representative and reviewed by a Government property administrator.

Agency Peculiar property represents the largest dollar value of assets owned by MSFC. Contractor-held agency peculiar property includes configurations of spacecraft, engines, satellites, rockets, and similar components unique to NASA space programs and held by

NASA prime contractors or their subcontractors who are responsible for building, refurbishing, and launching the hardware. Contractor reporting is required for cost-type contracts exceeding $500,000 where agency peculiar property costs exceed $75,000. These items are priced in accordance with guidance set forth in a NASA supplement to the FAR. The valuation policy allows for use of actual or estimated costs which may be abstracts of data from contractors' records, computations based upon engineering estimates, estimates from NASA contractor financial management reports, formula procedures, and latest acquisition/pricing estimates or other approved methods.

In FY 1998, NASA made significant changes in its property, plant and equipment accounting and reporting policies and practices. These changes were made in order to implement the requirements of SFFAS Number 6, Accounting for Property Plant and Equipment, and Number 8, Supplementary Stewardship Reporting. These changes applied to NASA's government-held property as well as its contractor-held property. The major changes included recognizing depreciation, capitalizing assets in space and reporting heritage assets only as supplementary stewardship information accompanying the financial statements.

Prior to FY 1998, NASA did not recognize depreciation of its assets. However, with the implementation of SFFAS Number 6 on October 1, 1997, NASA began to report depreciation expense on its financial statements. Depreciation expense is calculated on a composite basis, using the straight-line method. To determine depreciation expense, a variety of useful lives were established. Useful lives were set at 40 years for buildings, 15 years for other structures and facilities, 15 years for space hardware, 7 years for special test equipment and special tooling, and 5, 7, 10, 15, and 20 years for equipment, dependent upon its nature. In addition, a useful life of 25 years was established for the Space Shuttle Orbiters. As part of its implementation of the new accounting standards, NASA increased the threshold value for property to be capitalized from $5,000 to $100,000. Property of lesser value is expensed when purchased. However, NASA continues to maintain physical accountability for property, plant and equipment at lower values.

MSFC's FY 1998,1999, and 2000 financial statements reflect the valuation of its property, plant, and equipment based on NASA's revised capitalization threshold and the elimination of heritage assets. However, in accordance with NASA guidance, the values do not reflect depreciation.

Other Assets

Other assets are comprised entirely of government-owned/contractor-held materials.

Liabilities Covered by Budgetary Resources

Accounts payable include amounts recorded for receipt of goods or services furnished to the Center, based on receiving reports and billings rendered. Additionally, MSFC accrues cost and recognizes liability based on information that is provided monthly by contractors on cost and performance reports [NASA Form (NF) 533, Contractor Financial Management Report]. MSFC relies on independent audits by the DCAA to ensure the reliability of reported costs and estimates. To provide further assurance, financial managers are required to test the accuracy of cost accruals generated from the NF 533's, and NASA Headquarters independently analyzes the validity of MSFC's data.

Liabilities Not Covered by Budgetary Resources

Liabilities not covered by budgetary resources include unused annual leave and compensatory time and unliquidated obligations against closed appropriations.

MSFC has approximately $1.5 million recorded in accounts payable related to closed appropriations for which there is a contractual commitment to pay. These accounts payable will be funded from appropriations that are available for obligation at the time a billing is processed, in accordance with Public Law 101-510.

In addition, MSFC had $300 million in contingent liabilities as of September 30, 2000. These contingencies consist primarily of contract termination liability. However, the probability is remote that any payments will be due in the future related to these contingencies. Accordingly, no balances have been recorded in the financial statements as contingent liabilities.

Revenues and Other Financing Sources

MSFC receives the majority of its funding through multiyear appropriations. These include 3-year appropriations for construction activities, 2-year appropriations for operational and space flight activities, and a single year appropriation for civil service payroll and travel. In addition to appropriated funds, the Center performs services for other Federal agencies and the public and receives reimbursable funding authority.

2 Fund Balance With Treasury (In Thousands)

	Obligated	Unobligated		Total
		Available	Restricted	
Appropriated Funds	$947,970	$78,169	$3,422	$1,029,561
Trust Funds	0	139	0	139
Total	941,171	79,106	3,422	1,029,700
Deposit Funds				344
Clearing Accounts				1,549
Total Fund Balance withTreasury				**$1,031,593**

Obligated balances represent the cumulative amount of obligations incurred, which are supported by documentary evidence, for which outlays have not yet been made. Unobligated available balances represent the amount remaining in appropriation accounts that are available for obligation in the next fiscal year. Unobligated restricted balances represent the amount remaining in appropriation accounts that can only be used for adjustments to previously recorded obligations.

3 Accounts Receivable, Net (In Thousands)

	Entity Accounts Receivable	Nonentity Accounts Receivable	Allowance for Uncollectible Receivables	Net Amount Due
Intragovernmental	$1,923	$0	$0	$1,923
Governmental	601	2	0	603
Total Accounts Receivable	**$2,524**	**$2**	**$0**	**$2,526**

Nonentity accounts receivable represent amounts that will be deposited to miscellaneous receipts when collected and subsequently returned to the U.S. Department of the Treasury.

4 Operating Materials and Supplies (In Thousands)

	2000	1999	Valuation Method
Stores Stock	$1,683	$2,008	Weighted Avg.
Standby Stock	319	318	Weighted Avg.
Total Operating Materials and Supplies	**$2,002**	**$2,326**	

Stores stock represents material being held in inventory which is repetitively procured, stored, and issued on the basis of recurring demand. Standby stock represents material held for emergencies. These amounts are held for use in current operations. Excess, obsolete, and unserviceable items have been removed from these accounts.

5 Property, Plant, and Equipment (In Thousands)

	2000	1999	Change
Government-owned/Government-held			
Land	$0	$0	$0
Structures, Facilities & Leasehold Improvements	310,577	311,813	(1,236)
Equipment	180,217	195,505	(15,288)
Work in Process	1,562	4,570	(3,008)
Total	**$492,356**	**$511,888**	**($19,532)**

NASA is a party to an agreement with the Department of the Army for use and occupancy of the land on which the Marshall Space Flight Center is located. The agreement is irrevocable and can be renewed on June 30, 2059, at NASA's option. There is no cost to MSFC associated with this agreement.

Property, Plant, and Equipment (Continued)

	2000	1999	Change
Government-owned/Government-held			
Land	$7,162	$7,162	$0
Structures, Facilities & Leasehold Improvements	252,174	248,755	3,419
Equipment	176,892	156,382	20,510
Special Tooling	381,756	285,515	96,241
Special Test Equipment	148,433	123,798	24,635
Space Hardware	794,115	588,843	205,272
Work In Process	2,013,260	1,011,546	1,001,714
Total	**3,773,792**	**3,465,888**	**1,351,791**
Total Property, Plant and Equipment	**$4,266,148**	**$2,933,889**	**$1,332,259**

The decrease in the total PP&E value is due to the $1 billion reduction of work in process reported on the NF1018 for contract NAS 8 37710 with TRW. This reduction of work in process is due to the completion and launch in July 1999 of the TRW-built Chandra X-Ray Observatory, the world's most powerful x-ray telescope. TRW has been designing and producing spacecraft for NASA's most challenging space science missions for more than 40 years. The Chandra X-Ray Observatory program is managed by the Marshall Space Flight Center for NASA's Office of Space Science.

At the time of its July 1999 launch, Chandra became part of the government-owned/government-held assets known as Assets in Space. Assets in Space include various spacecraft that operate above the atmosphere for exploration purposes. These assets are accounted for and depreciated on NASA's balance sheet, rather than the managing installation's balance sheet. Assets in Space is a new category of assets which had (previous to FY 1998) been treated as an expense.

6 Other Assets (In Thousands)

	2000	1999	Change
Contractor-held Materials	$1,265,066	$1,087,680	$177,386
Total	**$1,265,066**	**$1,087,680**	**$177,386**

7 Other Liabilities (In Thousands)

Liabilities Not Covered by Budgetary Resources	Current	Noncurrent	Total
Intragovernmental Liabilities:			
*Liability for Deposit and Suspense Funds	$1,755	0	$1,755
Total	**$1,755**	**0**	**$1,755**
Governmental Liabilities:			
Accrued Funded Payroll and Benefits	$13,687	$0	$13,687
*Liability for Deposit and Suspense Funds	193	0	193
Liability for Statistical Reimbursable Costs	770	0	770
Total	**$14,650**	**0**	**$14,650**

*Liabilities include cash advances received from other Government agencies and public reimbursable customers. Also included are funds on deposit with the U.S. Treasury for employee's savings bonds and state tax withholdings.

Liabilities Not Covered by Budgetary Resources	Current	Noncurrent	Total
Intragovernmental Liabilities:			
Accounts Payable for Closed Appropriations	$0	$20	$20
Liability for Receipt Accounts	973	0	973
Total	**$973**	**$20**	**$993**
Governmental Liabilities:			
Accounts Payable for Closed Appropriations	$0	$1,444	$1,444
Liability for Receipt Accounts	(971)	0	(971)
Unfunded Annual Leave & Comp Time	0	18,933	18,933
Total	**($971)**	**$20,377**	**$19,406**

8 Net Position (In Thousands)

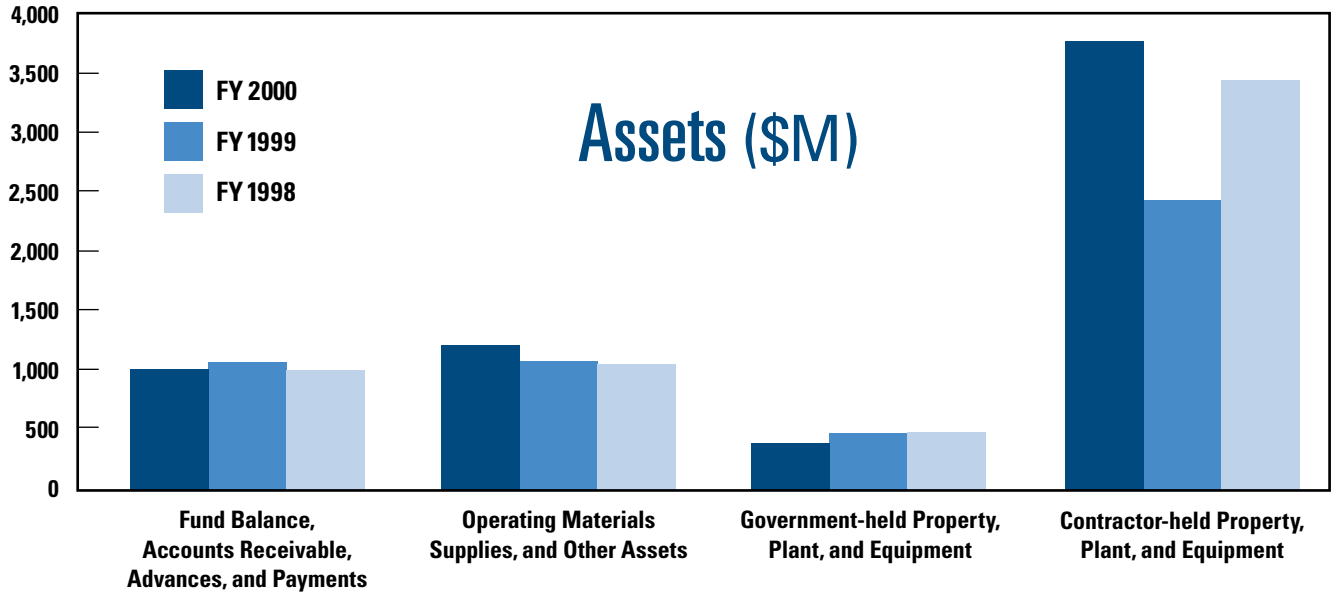
	Appropriated Funds
Unexpended Appropriations:	
Undelivered Orders	$346,957
Unobligated:	78,169
Available	3,422
Unavailable	5,533,023
Cumulative Results	3
Future Funding Requirements:	
Closed Appropriations	(1,464)
Annual Leave and Compensory Time	(18,933)
Total	**$5,941,177**

Supplemental Financial Information

Assets

MSFC's assets have fluctuated over the last 3 years, ranging from $6.1 billion in 1998 to $6.6 billion in 2000. The decrease in value from 1998 to 1999 was due to the reduction in contractor-held work in process reported by TRW based on the July 1999 launch of the Chandra X-Ray Observatory. The increase in value from 1999 to 2000 was due primarily to an increase in contractor-held work in process based on changes in pricing methodologies employed by two of MSFC's major contractors, Boeing/Rocketdyne Division and Lockheed Martin Corporation/Skunkworks, and an increase in work in process associated with the new RSRM (reusable solid rocket motor) production contract awarded to the Thiokol Corporation.

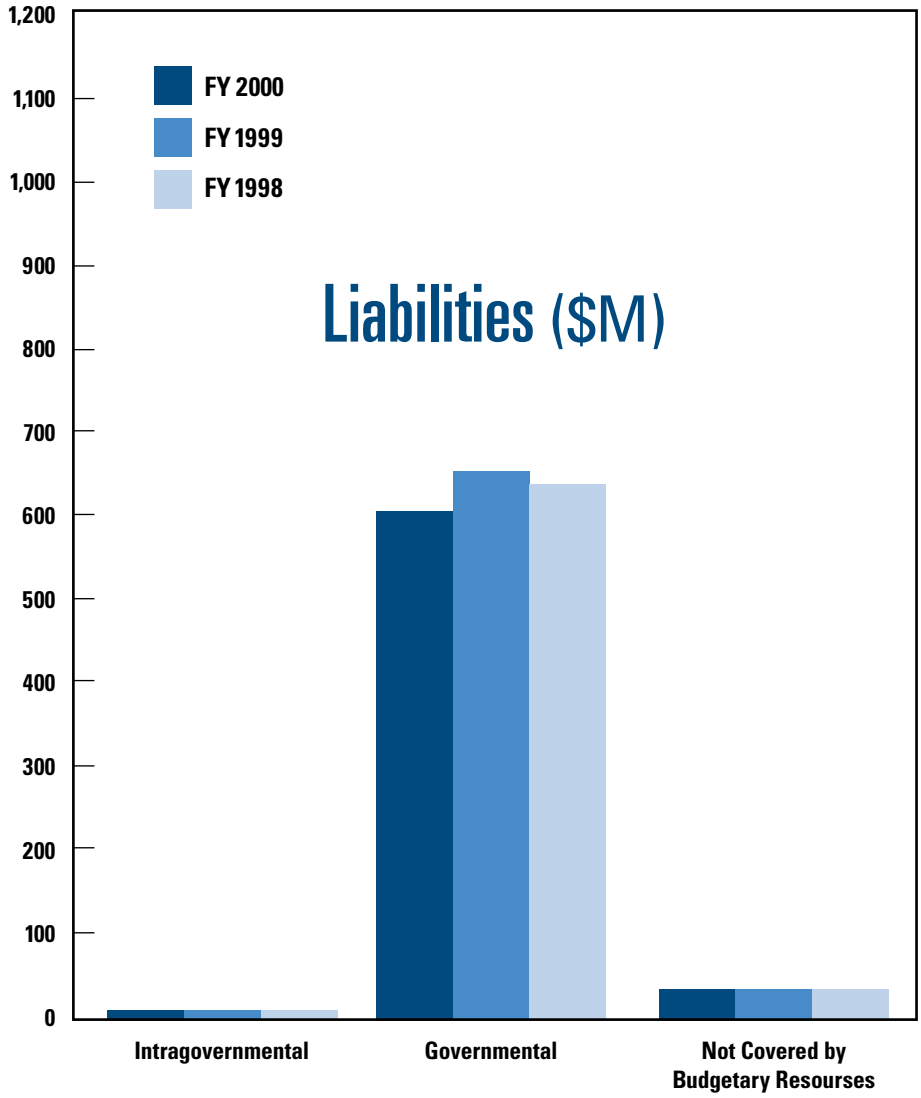
(In Thousands)	2000	1999	1998
Fund Balance, Accounts Receivable, Advances and Prepayments	$1,034,215	$1,054,750	$1,005,622
Operating Materials, Supplies, & Other Assets	1,267,068	1,090,006	1,081,827
Government-held Property, Plant & Equipment	492,356	511,888	516,947
Contractor-held Property, Plant & Equipment	3,773,792	2,422,001	3,465,888
Total Assets	**$6,567,431**	**$5,078,649**	**$6,070,284**



Liabilities

MSFC's liabilities have remained constant over the last three years at approximately $.6 billion.

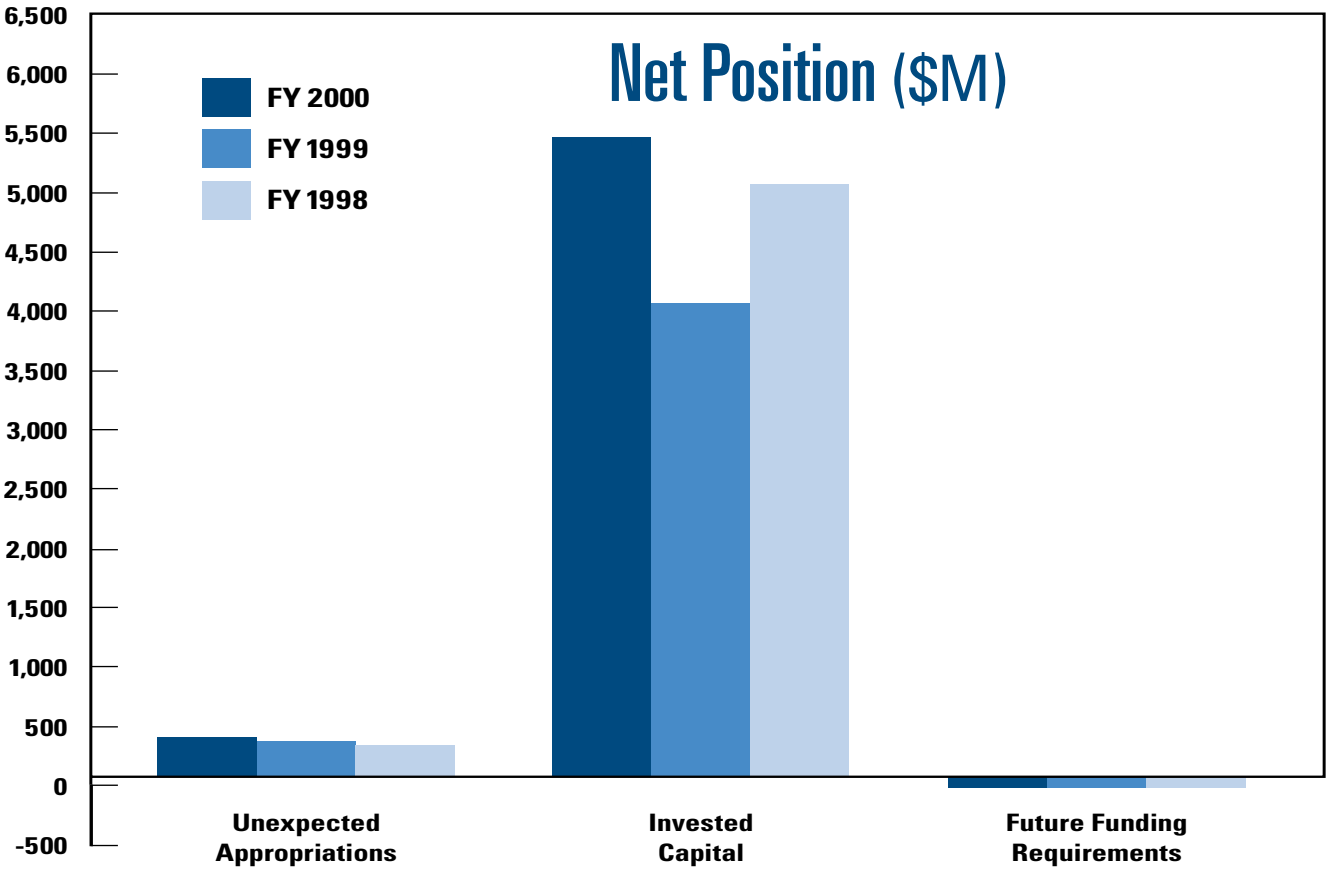
(In Thousands)	2000	1999	1998
Intragovernmental Liabilities	$12,463	$13,589	$15,697
Governmental Liabilities	596,392	645,615	626,343
Liabilities Not Covered by Budgetary Resources	20,399	20,067	21,170
Total Liabilities	**$626,254**	**$679,271**	**$663,210**
% of Total Assets	**10%**	**13%**	**11%**



Net Position

MSFC's net position has fluctuated over the last 3 years, ranging from $5.4 billion in 1998 to $5.9 billion in 2000. The $1 billion decrease in Invested Capital from 1998 to 1999 was due to the reduction in contractor-held work in process reported by TRW based on the July 1999 launch of the Chandra X-Ray Observatory. The $1 billion increase in Invested Capital from 1999 to 2000 was due primarily to an increase in contractor-held work in process based on changes in pricing methodologies employed by two of MSFC's major contractors, Boeing/Rocketdyne Division and Lockheed Martin Corporation/Skunkworks, and an increase in work in process associated with the new RSRM (reusable solid rocket motor) production contract awarded to the Thiokol Corporation.

(In Thousands)	2000	1999	1998
Unexpended Appropriations	$428,548	$395,546	$363,574
Invested Capital	5,533,022	4,023,895	5,064,661
Cumulative Results of Operations	4	3	0
Future Funding Requirements	(20,397)	(20,066)	(21,162)
Total Liabilities	**$5,941,177**	**$4,399,378**	**$5,407,073**
% of Total Assets	**90%**	**87%**	**89%**



Unexpended Appropriations includes the following:

(In Thousands)	2000	1999	1998
Unobligated Allotments	$81,591	$79,654	$125,503
Undelivered Orders	346,957	315,892	238,071
Total Unexpended Appropriations	**$428,548**	**$395,546**	**$363,574**

Invested Capital includes the following:

(In Thousands)	2000	1999	1998
Operating Materials and Supplies	$2,002	$2,326	$2,437
Contractor-held Materials	1,265,066	1,087,680	1,079,389
Government-held Property	490,794	507,318	508,080
Less: liability for capitalized leases	(193)	0	0
Construction in Progress	2,014,822	1,016,116	2,079,438
Contractor-held Property	1,760,532	1,410,455	1,395,317
Total Invested Capital	**$5,533,023**	**$4,023,895**	**$5,064,661**

Future Funding Requirements includes the following:

(In Thousands)	2000	1999	1998
Accounts Payable for Closed Appropriations	$(1,464)	$(951)	$(638)
Unfunded Annual Leave and Comp Time	(18,933)	(19,115)	(20,523)
Total Future Funding Requirements	**$(20,397)**	**$(20,006)**	**$(21,161)**

Prompt Payment Act Compliance

MSFC processed payments of $1.8 billion that were subject to the Prompt Payment Act, with 95.01 percent of its 21,703 payments being on time. Interest totaling $27,503.62 was paid on 455 late payments. In addition, discounts of $256,140.69 were taken on 442 payments which were made early to take advantage of discounts offered by vendors.

Acronym List

AA	advanced agreement
AAAS	American Association for the Advancement of Science
ACCESS	advanced cosmic-ray composition experiment for Space Station
ACTT	advanced computational technology team
ADA	Americans with Disabilities Act
AFM	atomic force microscope
AFOCL	Adjustable Focus Optical Correction Lens
AHRR	Advanced Very High-Resolution Radiometer
AMCOM	Army Aviation and Missile Command
AMPET	Aerospace Materials Processes and Environmental Technology
AMSD	Advanced Mirror System Demonstrator
AMSU	Advanced Microwave Sounding Unit
ANVIL	Army-NASA Virtual Innovations Library
APPL	Academy of Program and Project Leadership
APU	Auxillary Propulsion Unit
ARC	Ames Research Center
ASI	Agency Safety Initiative
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ASM	American Society for Microbiology
ATM	asynchronous transfer mode
AVO	automated vehicle operations
BAG	biotechnology ambient generic
BATSE	Burst and Transient Source Experiments
BMS	Bristol-Meyers Squibb
BPR	Biological and Physical Research (Office of)
C of F	construction of facilities
CAA	Clean Air Act
CaER	Customer and Employee Relation s Directorate
CBM	Common Berthing Mechanism
CCAD	Central American Commission on Environment and Development
CDDF	Center Director's Discretionary Fund
CDR	Critical design review
CDT	countdown time
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CERN	European Center for Nuclear Research
CIO	Chief Information Officer
CIR	Combustion Integrated Rack
CORE	Central Operation of Resources for Educators
CRK	carbon dioxide removal kit
CSC	Commercial Space Center
CWC	contingency waste container
CXM	Constellation –X Mission
DARPA	Defense Advanced Research Projects Agency
DCAA	Defense Contract Auditing Agency
DCMA	Defense Contract Management Agency
DFRC	Dryden Flight Research Center
DOD	Department of Defense

DSL	dynamic light scattering
DTV	digital TV
ECLSS	environmental controls and life support system
ED	Engineering Directorate
EGN	enhanced gaseous nitrogen
EMC	electromagnetic compatibility
EMS	electronic meeting system
ENSO	El Niño–southern oscillation
EPA	Environmental Protection Act
ERE	Extensional Rheology Experiment
ESA	European Space Agency
ESR	engineering support room
ET	External Tank
EUSO	Extreme Universe Space Observatory
EVA	extra vehicular activity
EVM	earned-value management
EXPRESS	expediting the process of experiments to Space Station
FAR	Federal Acquisition Regulation
FASAB	Federal Accounting Standards Advisory Board
FCF	first captive flight
FIR	Fluids Integrated Rack
FTE	full time employee
GBM	GLAST Burst Monitor
GFSSP	Generalized Fluid System Simulation Program
GHCC	Global Hydrology Climate Center
GLAST	Gamma-ray Large Area Space Telescope
GLIMIT	glovebox integrated microgravity isolation technology
GOES	Geostationery Operational Environmental Satellite
GRC	Glenn Research Center
GSA	General Services Administration
GSFC	Goddard Space Flight Center
HBCU	historically black colleges and universities
HOSC	Huntsville Operations Support Center
HRF	Human Research Facility
HSF	human space flight
HSI	Hispanic-serving institutions
HTS	high temperature superconducting
IAR	independent annual review
IBC	iterative biological crystallization
ICM	Interim Control Module
IFA	In-flight anomaly
IFF	International Flavors and Fragrances, Inc.
IFM	Integrated Financial Management
IFMP	Integrated Financial Management Plan
IPAO	Independent Program Assessment Office
ISAS	Institute for Space an Astronautical Science/Japan
ISE	intelligent synthesis environment

ISM	interim control module
ISRU	In situ resource utilization
ISS	*International Space Station*
JEM-EF	Japanese Experiment Module-Exposed Facility
JERS	Japanese Earth Resources Satellite
JG-PP	Joint Group on Pollution Prevention
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LASER	Learning About Science, Engineering, And Research
LED	Light-Emitting Diode
LEO	low-Earth orbit
LIS	Lightening Imaging Sensor
LIS	logistics information system
LLNL	Lawrence Livermore National Laboratory
LTMPF	low-temperature microgravity physics facility
M_2P_2	mini-magnetosphere plasma propulsion
MAF	Michaud Assembly Facility
MBC	Mesoamerican Biological Corridor
MOA	Memorandum of Agreement
MOU	memorandum of understanding
MPLM	Multi-Purpose Logistics Module
MRP	Microgravity Research Program
MS	mission support
MSAD	Microgravity Science and Applications Department
MSAT	Marshall safety and health action team
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MSL	Materials Science Laboratory
NACC	NASA automated data processing consolidation center
NAFCOM	NASA/Air Force Cost Model
NAIS	NASA Acquisition Internet Service
NAR	non–advocate review
NCAM	National Center for Advanced Manufacturing
NEI	National Eye Institute
NGST	Next Generation Space Telescope
NIST	National Institute of Standards and Technology
NMRT2	NASA Materials Replacement Technology Team
NMSC	NGST mirror systems demonstrator
NMSD	New Mirror System Demonstrator
NOAA	National Oceanographic and Atmospheric Administration
NOET	NASA Operational Environment Team
NPDMS	NASA property disposal management system
NRA	NASA research announcement
NRL	Naval Research Laboratory
NSF	National Science Foundation
NSN	NASA secure network

NSSTC	National Space Science and Technology Center
NSTC	National Science and Technology Council (was FCCSET)
OMB	Office of Management and Budget
OMU	other minority universities
OTD	operational technical documentation
OWL	orbiting wide-angle lens
P_2	pollution prevention
PAPAC	Provide Aerospace Products and Capailities
PARCS	primary atomic reference clock in space
PBE	pool boiling experiment
PCA	program commitment agreement
PCAM	protein crystallization apparatus for microgravity
PCG-EGN	protein crystal growth-enhanced gaseous nitrogen dewar
PCH	permanent human capacity
PCM	program commitment agreement
PCP	payload carriers program
PDR	preliminary design review
PEC	passive experiment carrier
PFA	portable fan assembly
PFC	Physics Frontier Center
PHC	program critical hardware
PKI	public key infrastructure
PLZT	lead lanthanum-modified zirconate titanate
PMA	pressurized mating adapter
PMAD	power management and distribution
PMC	Program Management Council
POIC	payload operations and integration center
POP	program operating plan
PP&E	Property, Plant and Equipment
PPDB	past performance database
ProSEDS	Propulsive Small Expendable Deployer System
QCM	quartz crystal microbalance
QMI	quench module insert
R&D	Research and Development
R&PM	Research and Program Management
RAID	redundant array of independent disks
RDR	requirements definition review
RLV	reusable launch vehicle
RMS	reliability maintainability supportability
RSRM	reusable solid rocket motor
RSTS	reusable space transportation system
S&MA	Safety and Mission Assurance Office
SAIC	Science Applications International Corporation
SAL-6	spread across liquids
SAT	science, aeronautics and technology
SBIR	Small Business Innovative Research
SBMD	subscale beryllium mirror demonstrator
SCR	science concept review

SDB	small disadvantaged business
SEA	Shuttle Environment Assurance Initiative
SEE	space environment and effects
SERT	space solar power exploratory research and technology
SESAAS	Sustaining Engineering Support for Agencywide Administrative Systems
SEWG	Systems Engineering Working Group
SFCDC	space flight control and data communications
SFFAS	Statement of Federal Financial Accounting Standards
SFOC	space flight operations contractor
SGR	soft gamma ray repeater bursts
SHE	Safety, Health, & Environmental Committee
SIBOA	systematic image-based optical alignment
SLWT	super lightweight tank
SMO	Systems Management Office
SNG	science.NASA.gov
SOMTC	Space Optics Manufacturing Technology Center
SPARCLE	Space Readiness Coherent Lidar Experiment
SPD	Space Product Development
SPG	solar power generation
SRB	solid rocket booster
SRB	surface radiation budget
SSME	Space Shuttle Main Engine
SSP	space solar power
SSPO	Space Shuttle Projects Office
SSRMS	space station remote manipulator system
SSWP	supervisors safety web page
STTR	Small Business Technology Transfer
TIP	Technology Investment Program
TreK	Telescience Resource Kit
TRI	toxic chemical release inventory
TRL	test readiness list
TRMM	tropical rain measuring mission
TVC	thrust vector control
UAB	University of Alabama at Birmingham
UAH	University of Alabama at Huntsville
UPA	urine processor assembly
UPS	uninterruptible power supply
UTC	coordinated universal time
VCD	vapor compression distillation
VCD FE	Vapor Compression Distillation Flight Experiment
VISAR	Video Image Stabilization and Registration
VPO	Virtual Procurement Office
VPP	Voluntary Protection Program
WPT	wireless power transmission
XCF	X-Ray Crystallization Facility
XMM	X-Ray Multi Mirror Telescope
XRCF	X-Ray Calibration Facility

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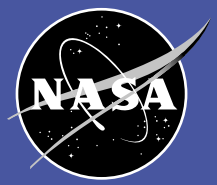

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